UNITED STATES
DEPARTMENT OF THE INTERIOR
J. A. KRUG, Secretary
GEOLOGICAL SURVEY
W. E. WRATHER, Director

PROGRESS REPORT
ON
GROUND-WATER RESOURCES
OF THE
SOUTHWESTERN PART OF BROOME COUNTY, NEW YORK

By

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Prepared in cooperation with the

New York Water Power and Control Commission

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ABSTRACT

In cooperation with the New York State Water Power and Control Commission the Geological Survey, United States Department of the Interior, is currently investigating the geology and ground-water resources of New York State. The areas selected for initial study are those in which pumpage from ground-water storage is already heavy. This report presents the information gathered to date for the southwestern part of Broome County where the so-called "Triple Cities" of Binghamton, Johnson City, and Endicott are rapidly developing one of the largest concentrations of ground-water pumpage in the State.

Included in this report is a brief geologic history of the area with a discussion of the principal geologic formations; records of 58 wells and 30 borings; pumpage figures for the principal ground-water supplies, covering a period of 8 years; hydrographs showing variations in ground-water levels for the same period; precipitation and runoff data for the same period; typical chemical analyses of water samples collected from 21 wells and 5 surface-water sources; and a limited amount of data regarding ground-water temperatures.

Examination of the assembled data suggests that the present development of ground water in this area at critical times approaches 40 percent of the total available supply while on the average it approximates from 20 to 25 percent. The data further suggest the general location and extent of the preglacial valleys and some of the areas in which satisfactory supplies of potable ground water are known to exist. The report indicates that further development of ground-water supplies in the area

should avoid the vicinities of existing well fields where wells are already badly overcrowded and should take advantage of certain other selected and as yet undeveloped parts of the area where existing natural features suggest the presence of satisfactory ground-water supplies.

The report concludes by pointing out some of the obvious phases of the investigation requiring additional work and study to furnish information now entirely missing or only partly known.

INTRODUCTION

Purpose and scope of investigation

In the early part of 1942 the War Production Board of the United States, charged with the responsibility of approving locations for new war plants and expansions to existing plants, requested the United States Geological Survey to furnish information regarding the water resources of all areas in which satisfactory municipal or industrial water supplies had already been developed. Accordingly the Geological Survey, together with its cooperating agencies, initiated a program for reconnoitering the desired areas and prepared preliminary unpublished reports that were furnished to the War Production Board. Among the areas investigated in New York State was the southwestern part of Broome County, where municipal and industrial interests of the so-called "Triple Cities" of Binghamton, Johnson City, and Endicott were already developing large ground-water supplies.

The purpose of this report is to present the reconnaissance information gathered in the field by J. G. Ferris during November 1942, by E. S. Simpson in July 1945, and by R. H. Brown in December 1945, together with the conclusions that may be drawn therefrom. The pressing need for information on this part of New York State to prevent overdevelopment, yet permit the maximum safe development, of the ground-water resources prompts the release of this report while additional data are still being collected.

Acknowledgments

The authors are grateful to many officials of the State, of municipalities, of large industrial concerns, and of small independent enterprises, as well as numerous drillers and private individuals, all of whom furnished valuable data for use in this report. Among those who were particularly helpful are: F. W. Gilcreas, assistant director, New York State Department of Health Laboratory in Albany; S. P. Carman, superintendent-engineer, Bureau of Water, City of Binghamton; J. A. Giles, city engineer, Binghamton; Burt E. Nelson, of Nelson and Lauder, Chemists and Bacteriologists, Binghamton; K. Braun of the Ansco Corporation Engineering Department, Binghamton; Arthur J. Merrill, superintendent, Johnson City Water Department; Earl J. Grippen, superintendent, and Tweed Main, assistant, Endicott Water Works Company; J. V. Martz, Plant Engineering Department, International Business Machines Corporation, Endicott; Harley Murphy, superintendent, Vestal Water Department; J. W. Gevert, superintendent, Hillcrest Water District No. 1, Town of Fenton.

Further acknowledgments are gratefully made to Russell Suter, executive engineer of the New York State Water Power and Control Commission; John Broughton, Assistant State Geologist; C. R. Cox, chief, Bureau of Water Supply, New York State Department of Health; E. J. Christie, meteorologist, U. S. Weather Bureau office in Albany; and colleagues in the United States Geological Survey who reviewed the manuscript. E. S. Asselstine of the Geological Survey prepared the geologic section of this report and E. S. Simpson of the Geological Survey collected part of the basic data. Appreciation is expressed to A. W. Harrington, district

engineer, U. S. Geological Survey, Surface Water Division office in Albany, for his review of the surface-water section of this report.

Previous reports and investigations

Official bulletins of the New York State Museum cover the general geology of the State and a report by Fairchild1/ presents interesting hypotheses regarding the geologic history of part of the area covered by this report. A report by Lohman2/ describes the geology and ground-water resources in northeastern Pennsylvania bordering the southwestern part of Broome County, New York.

The United States Weather Bureau has maintained observations at Binghamton since July 1890 and the United States Geological Survey has on file records of the stage and discharge of the Susquehanna River at Conklin since 1912; at Binghamton from 1901 to 1912, inclusive, (subsequent stage records only are available from the Weather Bureau); at Vestal since March 3, 1937; and for the Chenango River near Chenango Forks since 1912.

A bibliography of the literature pertinent to this area is included at the end of this report.

1/ Fairchild, Herman L., The Susquehanna River in New York and evolution of western New York drainage: N. Y. State Mus. Bull. 256, Jan. 1925.

2/ Lohman, Stanley W., Ground water in northeastern Pennsylvania: Pa. Geol. Survey Bull. W-4, 1937.

Location and description of the area

This report covers the southwestern part of Broome County, in the south-central part of New York State, on the New York-Pennsylvania State line. Figure 1 illustrates the geographic location and extent of the area with respect to New York State, and figure 2 is a detail map of the specific area covered.

Broome County lies in the southeastern part of the physiographic section of the state designated by Miller[3] as the "southwestern plateau province". The boundaries or limits of this province, significant to the water resources of Broome County, are the Catskill Mountains on the east and the Helderberg escarpment on the north. The Catskill Mountains contain the drainage divide between some of the water that flows west and southwest, eventually to reach Broome County, and the water that flows east or southeast into the Hudson River valley. The Helderberg escarpment forms the drainage divide between water that flows south, eventually reaching Broome County, and water that flows north into the Mohawk Valley and thence eastward into the Hudson Valley.

Although Miller[4] has used the term "plateau" in naming this large physiographic section of New York State, it should be recognized as a general term. The southwestern part of Broome County would hardly convey the impression of a plateau to the casual observer. The Susquehanna

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3/ Miller, Wm. J., The geological history of New York State: N. Y. State Mus. Bull. 255, p. 17, Nov. 1924.

4/ Miller, W. J., op. cit., pp. 18-20 (see footnote 3).

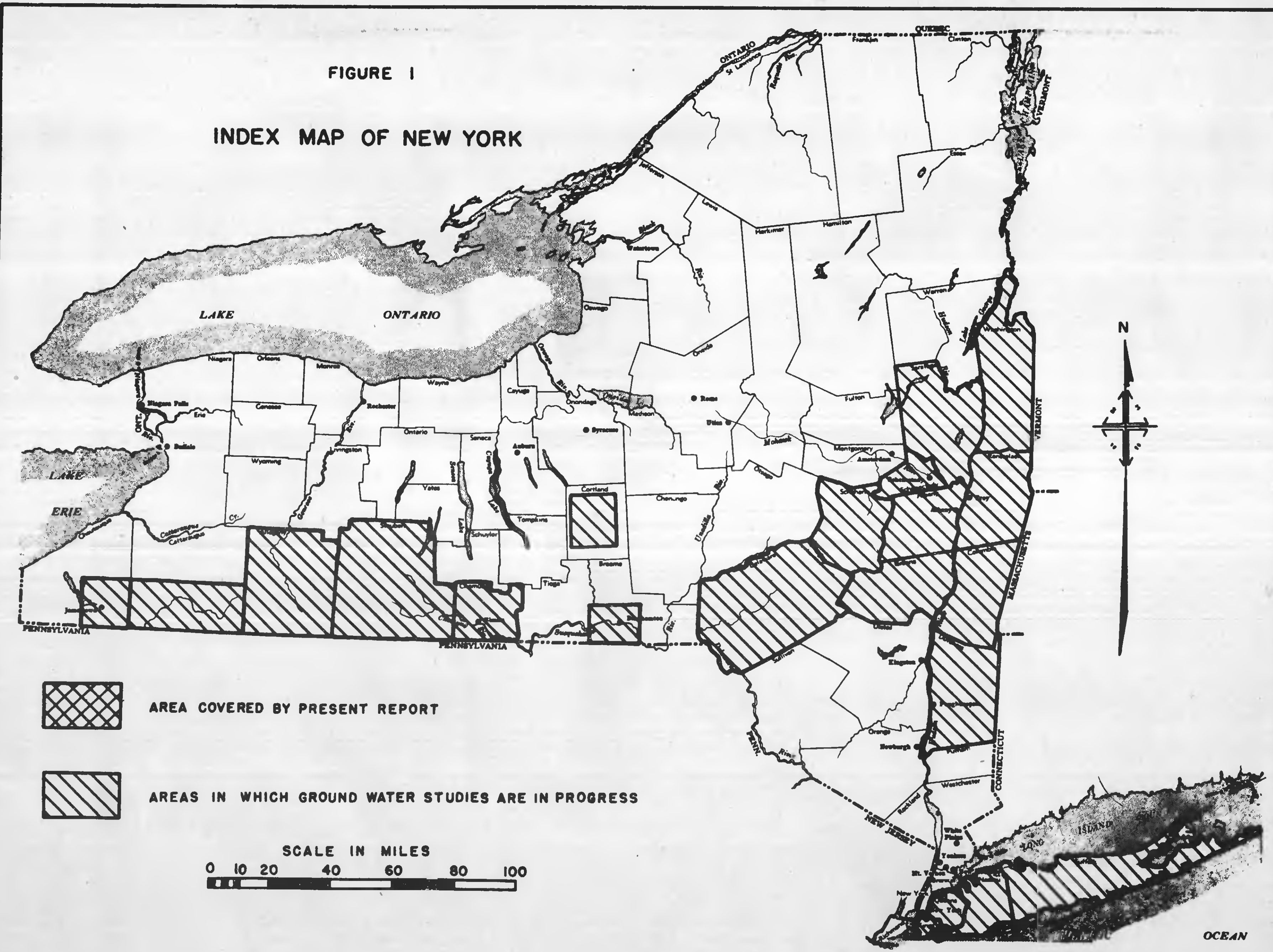
River, flowing from east to west through the area, and the Chenango River, entering the Susquehanna from the north at Binghamton, have carved broad valleys as much as $1\frac{1}{2}$ miles wide in the old plateau. Viewed from the floors of these valleys the area appears mountainous, but further investigation indicates that many of these "mountains" have a crest line at or near an elevation of 1,400 feet above mean sea level. Effects of erosion, therefore, have dissected the original plateau almost beyond recognition.

The so-called Triple Cities of Binghamton, Johnson City, and Endicott are on the broad valley floors mentioned above, at altitudes ranging from 830 feet to 900 feet above mean sea level. The combined population of these cities, together with several adjacent towns, is about 125,000. More than 100 industries in this area manufacture a diversity of products including shoes, clothing, chemicals, cameras, films, aviation devices, auto hardware, motor trucks, and electric and foundry items.

Plates 1, 2 and 3, prepared from photos furnished through the courtesy of the Binghamton Chamber of Commerce, afford aerial views of the area.

FIGURE I

INDEX MAP OF NEW YORK



11259

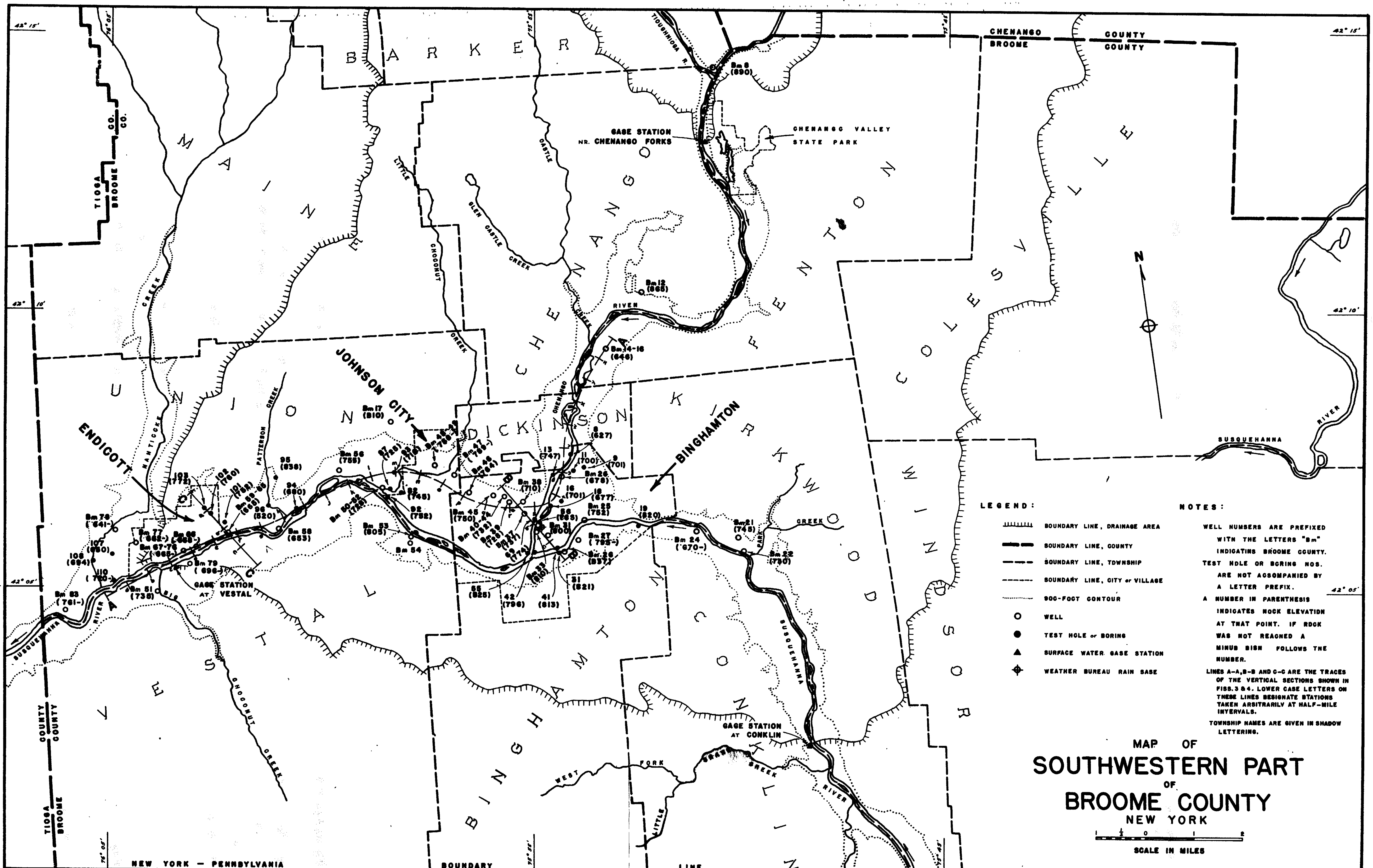

MAP OF
SOUTHWESTERN PART
OF
BROOME COUNTY
NEW YORK
SCALE IN MILES
LEGEND:
BOUNDARY LINE, DRAINAGE AREA
BOUNDARY LINE, COUNTY
BOUNDARY LINE, TOWNSHIP
BOUNDARY LINE, CITY or VILLAGE
900-FOOT CONTOUR
WELL
TEST HOLE or BORING
SURFACE WATER GAGE STATION
WEATHER BUREAU RAIN GAGE
NOTES:
WELL NUMBERS ARE PREFIXED WITH THE LETTERS "Bm" INDICATING BROOME COUNTY.
TEST HOLE OR BORING NOS. ARE NOT ACCOMPANIED BY A LETTER PREFIX.
A NUMBER IN PARENTHESIS INDICATES ROCK ELEVATION AT THAT POINT. IF ROCK WAS NOT REACHED A MINUS SIGN FOLLOWS THE NUMBER.
LINES A-A, B-B AND C-C ARE THE TRACES OF THE VERTICAL SECTIONS SHOWN IN FIGS. 3 & 4. LOWER CASE LETTERS ON THESE LINES DESIGNATE STATIONS TAKEN ARBITRARILY AT HALF-MILE INTERVALS.
TOWNSHIP NAMES ARE GIVEN IN SHADOW LETTERING.
CHENANGO COUNTY
BROOME COUNTY
TIOGA CO.
BROOME CO.
BARKER
MAINE
CHENANGO
FENTON
COLESVILLE
UNION
DICKINSON
KIRKWOOD
WINDSOR
VESTAL
BINGHAMTON
CONKLIN
ENDICOTT
JOHNSON CITY
BINGHAMTON
GAGE STATION NR. CHENANGO FORKS
CHENANGO VALLEY STATE PARK
GAGE STATION AT VESTAL
GAGE STATION AT CONKLIN
SUSQUEHANNA RIVER
CHENANGO RIVER
TIOUGHNIOGA R.
NANTICOKE CREEK
LITTLE CHOCONUT CREEK
CASTLE CREEK
GLEN CASTLE CREEK
PATTERSON CREEK
CHOCONUT CREEK
BIG CHOCONUT CREEK
WEST FORK
LITTLE SNAKE CREEK
PARK CREEK
NEW YORK – PENNSYLVANIA BOUNDARY LINE
R.H.B. 6-15-46

FIGURE 2

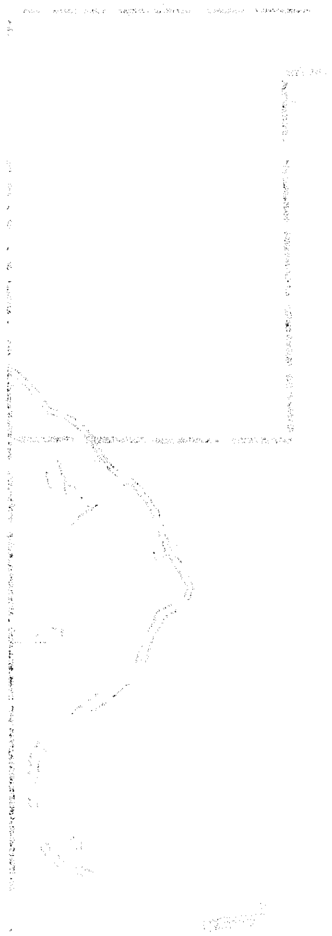


Photo furnished through courtesy of the Binghamton Chamber of Commerce

View of downtown Binghamton, looking north up the Chenango River valley from a point nearly over the Susquehanna River. Junction of the Chenango and Susquehanna Rivers is just below the lower left limit of the picture. In the left foreground is the Court Street bridge spanning the Chenango River, and proceeding upstream there appear in order the Ferry Street bridge, the Delaware, Lackawanna, and Western Railroad bridge, and the Erie Railroad bridge. Above the railroad bridges the irregular white line indicates a dam and just beyond and to the right of the wooded island above the dam careful scrutiny will reveal the gray steel truss bridge at De Forest Street. The broad open area to the right (east) of the river and between the dam and the De Forest Street bridge is known as Stowe Flats.

These key reference points may prove helpful in locating some of the wells, borings, and local areas discussed in later sections of this report. The angle at which this picture was taken does not show, to good advantage, the true profile of the Chenango Valley. For example, the well-rounded, partially-wooded hill in the left center background rises from an elevation of 850 feet at the valley floor to a crest of 1,420 feet above mean sea level.

Photo furnished through courtesy of the Binghamton Chamber of Commerce

View of downtown Binghamton looking, southeast from a point near the west bank of the Chenango River. The Erie and Delaware, Lackawanna, and Western railroad bridges spanning the Chenango River appear in the right foreground with the Ferry Street bridge in the extreme lower right corner. The Susquehanna River flows from left to right through the central part of the picture. The Binghamton water plant is located a little to the left of the large gas tank on the bank of the Susquehanna River near the left center of the picture. One of the plant's raw-water intake cribs is visible near the middle of the river just to the left of the tank. The first line of hills just beyond the Susquehanna River toward the background of the picture rises to an average altitude of approximately 1,500 feet. Immediately behind these hills is the broad Susquehanna valley in the vicinity of the village of Conklin.

Photo furnished through courtesy of the Binghamton Chamber of Commerce

View of the "Triple Cities" area looking northwest from a point approximately over the south bank of the Susquehanna River just below Rockbottom Dam. Junction of the Chenango and Susquehanna Rivers is just visible at the lower left corner of the picture. The broad valley floor on which most of the residential and business sections of the "Triple Cities" have developed is well shown. The wooded hills along the northside of the valley do not show to quite as good advantage.

Near the left margin of the picture, at the far edge of the thickly settled area, two tall smokestacks are visible. These are part of the Westover Station of the New York State Electric and Gas Corp. The Johnson City water plant and well field are immediately beyond and to the right of these stacks.

If the tongue of wooded land, originating at the right center edge of the picture, is followed out it will point to a group of large buildings comprising part of the Ansco plant. The well field is located just beyond these buildings.

Climate

Records maintained by the United States Weather Bureau at Binghamton for 54½ years (July 1890 through 1944) are representative of the climate in the area covered by this report. Over this period of record average figures for monthly and annual precipitation and mean temperature are as follows:

Table of average monthly and annual precipitation and mean temperature

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.
Average Precip. in inches.*	2.27	2.19	2.81	2.72	3.29	3.43	3.50	3.52
Average mean temp. in °F*	24.7	24.1	33.5	45.4	57.3	66.0	70.5	68.3

	Sept.	Oct.	Nov.	Dec.	Annual
Average Precip. in inches.*	3.12	2.98	2.28	2.30	34.41
Average mean Temp. in °F*	61.9	50.4	38.5	28.4	47.5

From the above table it is apparent that the distribution of precipitation through the year is fairly uniform, ranging only from a low of 2.19 inches in February to a high of 3.52 inches in August. However, appreciable departures from these averages have occurred. The floods of March 19, 1936, which exceeded anything previously on record, were preceded by a thaw, beginning on March 9, and a total precipitation of 5.13 inches through March 19. Unmelted snow on the ground at the end of February was about 8 inches. Precipitation for the entire month of March finally totaled 6.24 inches. This represented an excess of 3.43 inches over the normal precipitation.

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* Taken from unpublished records of the U. S. Weather Bureau. Subject to revision.

On March 28, 1913, the second-largest floods on record occurred, preceded by a thaw, beginning on March 8, and precipitation totaling 3.78 inches through March 28. Precipitation for the entire month of March was 3.91 inches.

Two notable periods of deficient rainfall have been observed. In August 1913, the precipitation totaled only 1.43 inches, and until September 16, when the lowest stream flows on record for this area occurred, only 0.02 inch of additional rain had fallen. Again on August 18, 1939, near-record lows in stream flow occurred after a total precipitation for July of only 1.24 inches and for August (prior to August 18) of only 0.64 inch.

Referring again to the preceding table, it is noted that the average value for annual mean temperatures over the $54\frac{1}{2}$-year period of record is 47.5° F. Variations in annual mean temperatures have not been great, ranging from a low of about 43° F. to a high of about 49° F. At present no significant persistent trend toward a milder or more severe climate is indicated. Rafter[5/] divided New York State into ten climatic areas which he termed "natural meteorological divisions". Broome County is in the south-central part of his "Eastern Plateau" division. Meteorological records maintained for an 11-year period (1891-1901, inclusive) in each of these ten climatic areas showed a variation in average annual precipitation from 34.46 inches in the Central Lakes area to 46.71 inches in the Atlantic coast area, and a variation in average annual mean temperatures from 42.2° F. in the northern plateau area to 50.9° F. in the Atlantic

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5/ Rafter, G. W., Hydrology of the State of New York: N. Y. State Mus. Bull. 85, p. 50, May 1905.

coast area. Thus the part of Broome County covered by this report appears to have an average annual mean temperature slightly above the average for the State, and an average annual precipitation below the average for the State.

Geology

Devonian rocks. The bedrock underlying the Binghamton quadrangle and the eastern part of the Apalachin quadrangle belongs to the Upper Devonian series and consists of sandy shales, thin-bedded sandstones and flags, and a few thin bands of impure limestone. In spite of the predominance of sandstones these rocks are generally tight and have low permeability. The rock formations were laid down in a shallow sea and after deposition were gradually elevated above sea level. At present the beds of rock are essentially horizontal. However, they have, in general, a regional dip to the south of about 40 feet per mile. Outcropping beds successively younger in age are encountered from north to south across this area because of the southward dip. Superimposed upon the dip is a series of low folds. The axes of the more or less parallel folds trend in a general east-west direction. In addition to the folding, the rocks also have two sets of nearly vertical joints or cracks. According to Wedel[6/] one set is approximately perpendicular to the folds and the other is approximately parallel with them. Most of these openings cut the rocks at right angles to the bedding planes and are generally vertical. The well-developed systems of joints provide channels in which ground water moves.

Since the uplifting above sea level that followed Devonian deposition

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6/ Wedel, A. A., Geologic structure of the Devonian strata of south-central New York: N. Y. State Mus. Bull. 294, p. 33, 1932.

the Binghamton area has been more or less continuously exposed to the forces of erosion, which have produced a maturely-dissected topography. The present major features of relief were, for the most part, produced by normal stream erosion of the nearly horizontal shales and sandstones.

Pleistocene and Recent deposits. Near the end of this long period of erosion a continental glacier invaded New York State. The glacier modified some of the major features of relief and developed many minor features. Glacial erosion and deposition profoundly affected the character of existing drainage and produced the conditions which make possible the large supply of ground water in the Binghamton region.

The erosional effects of glaciation will be considered first. Holmes[7] states that, from the results of glacial studies made thus far, there seems to be general agreement that the uplands of the Allegheny Plateau section of New York State have undergone only slight modification by the continental glaciers, principally by deposition. There are several evidences in the Binghamton area that the ice covering the uplands apparently was relatively inactive and failed to change the topography notably. Quantities of residual soil, even on the hilltops and open areas, were not removed. Many prominent cliffs show angular form. Glacial striae or scratches are light and suggest weak ice erosion.

In contrast to the uplands the amount of ice erosion appears to have been great in the main preglacial valleys, the location of which in their larger features is believed to have been essentially that of the present land surface. Especially did the glacier modify the large valleys which

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7/ Holmes, C. D., Glacial erosion in a dissected plateau: Am. Jour. Sci., 5th ser., vol. 33, p. 218, 1937.

were roughly parallel to the main ice movements. Glacial striae found on the upland surfaces give a clue to the direction of ice movement. The general direction in the Binghamton region seems to have been southwesterly and westerly. There is considerable variation, however, even in small areas, which indicates that the direction of ice movement differed somewhat at different times. The courses of the present Chenango and Susquehanna river valleys, and to some degree that of the Nanticoke Creek valley, lie parallel to the general direction of ice movement and show the greatest evidence of ice erosion. Along these main valleys are many tributary valleys which were not extensively deepened. The difference in elevation of the rock floors near the junctions of these hanging valleys and the deepened valleys is clear evidence of the great amount of erosion in the latter. Reference to the topographic maps of the Apalachin and Binghamton quadrangles will show the straight and open nature of the large valleys. A number of truncated spurs may be found that resulted from the removal by the ice of spurs of bedrock extending into these valleys. Further testimony of extensive ice erosion is the broad, U-shaped cross-section of the large valleys. The steep walls and the rounded bottoms of their bedrock profile is shown by the records for wells and borings which extend to solid rock (see fig. 4, sections B-B and C-C). The longitudinal profile of the rock floor of the Chenango and Susquehanna Valleys indicates that it may have a gradient opposite to the direction of present-day drainage (see fig. 3, section A-A, boring 8 to Bm 46). However, this is uncertain because some of these wells and borings may not lie close to the trace of the deepest part of the rock floors of the Chenango and Susquehanna valleys

and thereby may give rock elevations that are misleading. If a reverse gradient does exist, stream erosion could not have produced such a gradient. The direction of movement of glacial ice is dependent in large measure on the surface gradient of the ice and glaciers scour the rock floors in valleys in some places to a grade opposite to the direction of advance of the ice.

The deposits of the continental glacier and the weathered material derived from them constitute a large part of the soil in the Binghamton region. Spread over most of the area is a veneer of glacial till composed of a mixture of clay and larger rock fragments, the composition and depth of which differ from place to place. According to Lounsbury and others[8] the soils of the uplands in Broome County were derived largely from fine-grained sandstones and shales underlying the soil mass but they are not strictly residual because the glaciers brought in some foreign materials. These, however, are more plentiful in the valleys than on the uplands. Holmes[9] points out, with reference to the thickness of some of the deposits, that the terminal drift is strongly concentrated in the valleys, whereas on the uplands it is so limited as to make the recognition of continuous moraines difficult and uncertain. According to Tarr[10] wells from 10 to 20 feet deep usually pass through the drift sheet to the rock

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8/ Lounsbury, C., Hasty, A. H., Kinsman, D. F., Baran, J. H., Soil survey of Broome County, New York: U. S. Dept. Agr., Bur. Chemistry and Soils Series, No. 11, pp. 11-12, 1932.

9/ Holmes, C. D., Glacial erosion in a dissected plateau: Am. Jour. Sci., 5th ser., vol. 33, p. 222, 1937.

10/ Williams, H. S., Tarr, R. S., and Kindle, E. M., Geol. Survey Atlas, Watkins Glen-Catatonk folio. No. 169, p. 16, 1909.

almost everywhere except in the valley bottoms. Also, the smaller valleys away from the main streams are not, as a general rule, deeply filled with drift, but here and there wells reveal such a depth as to indicate the presence of buried valleys. Tarr states further that the main valleys and the lower portions of some of the larger valleys tributary to them are deeply filled.

A contrast in the character of deposition may be noted not only between the valleys and uplands but also between the northern and southern parts of the Binghamton and Apalachin quadrangles. Distinct deposits of two separate drift sheets, named the Olean and Binghamton drifts by MacClintock and Apfel,[11] are recognized. The southern border of the Binghamton drift, the younger of the two, is marked by the Binghamton moraine. This moraine has been traced along the south side of the Susquehanna River from the western boundary of the area covered by this report to Binghamton and from Binghamton up the Chenango Valley to the Broome County boundary. The Binghamton drift sheet itself seems to be much more prominent in topographic expression than that of the Olean drift, part of which it crossed. The Olean drift extends across the Binghamton and Apalachin quadrangles south from the Binghamton moraine. It is described by MacClintock and Apfel as a thin and topographically relatively unimportant drift sheet which differs strikingly from the Binghamton drift in the lack of both igneous erratics and limestones. The thin covering of glacial till and the morainal deposits are, in general, only moderately

11/ MacClintock, P., and Apfel, E. T., Correlation of the drifts of the Salamanca re-entrant, New York: Geol. Soc. of Am. Bull., vol. 55, p. 1155, 1944.

permeable because they are composed of a mixture of fragments which have a great range in size.

The glacial deposits contained in the Susquehanna and Chenango Valleys are principally of three types: outwash sands and gravels, lake clays, and morainal deposits. The character of the outwash gravels and the lake clays is particularly important with reference to ground-water supply in this region. The outwash was deposited by streams supplied by meltwater emerging from the glacier that were heavily laden with sediments. The sediments range from silt to coarse gravels and occur in beds that show a fair degree of sorting. They are very permeable, in contrast to the morainal deposits. Logs of wells and borings indicate that most of the beds of outwash are probably interconnected. The thickness of the beds differs even in short distances. This difference was probably caused by the erratic shifting of the channels of the glacial-fed streams. Lakes existed at different times in the valleys close to the ice, where the valleys sloped toward the ice or where morainal dams existed downstream. Fine materials were deposited over the bottoms of these lakes. This is revealed in most of the logs of wells and borings by the occurrence of different thicknesses of clay and silt. Where the clays extend over large areas ground water underlying the clay beds may occur under artesian pressure. The outwash deposits, the most extensive of the three types occurring in the valleys, are rather limited in horizontal extent. They are bounded by the relatively impermeable rock walls of the valleys. The total thickness of valley fill is considerable, as shown by logs of wells and borings in the deeper parts of the old valley channels. A number of

the logs show no rock at depths of 170 feet below the flat surface of the valley floors, and in well Bm 96 rock is reported to occur at a depth of 346 feet below the land surface.

Postglacial erosion has had relatively little influence on the deposits formed during the ice age. Some deposits have been removed and redeposited on the flood plains bordering the streams and in alluvial fans formed where upland streams enter the larger valleys. The narrow strip of Recent deposits bordering the main rivers is relatively shallow. Present drainage has little effect on the main valley features but rather is influenced by the features themselves.

GROUND WATER

Occurrence

As indicated in the geologic section of this report, the rock formations in Broome County belong to the Devonian system and consist primarily of shales and sandstones. They were laid down in flat sheets or beds of vast areal extent and were later tilted slightly (30 to 50 feet per mile according to Miller[12/]) to the south or southwest. Subsequent development of streams over the area gradually dissected the original beds, forming many valleys. The larger streams carved valleys as deep as 800 feet, measured from the top of the original plateau to the valley floor. Later deposition of clays, sands, and gravels on these valley floors provided natural underground reservoirs for the storage of ground water.

12/ Miller, William J., op. cit., p. 18 (see footnote 3).

In the southwestern part of Broome County the present Chenango and Susquehanna Rivers have deposited on their old valley floors clays, sands, and gravels ranging up to more than 200 feet in total thickness (see log of well Bm 14). In figure 2 the 900-foot contour line has been traced to indicate the approximate present boundaries of the Chenango and Susquehanna River valley floors. Above this contour the valley slopes rise steeply to an average elevation of about 1,400 feet above mean sea level. Below the 900-foot contour the valley floors are fairly level. The bulk of the industrial, commercial, and residential development of the area lies within this contour.

All of the principal potable ground-water supplies in this area are derived from wells developed in the river gravels of the old valley bottom. Because of the random deposition of the gravels, however, it is difficult to predict exact locations at which successful wells may be drilled and developed. General areas of good yield may be selected by studying records of existing wells, test wells, and borings. Records of 58 wells and 30 borings are given at the end of this report.

Because the beds available for ground-water storage are thickest in the lowest-lying parts of the old river valleys, it is pertinent to the selection of areas of high yield to determine the course of the old Susquehanna and Chenango River channels. The locations of all wells and borings used in this report have been plotted in figure 2. As indicated in the legend, the figures in parentheses show elevations of the underlying rock, and where no rock was reached a minus sign follows the figure. The broken curved line drawn through the present Chenango and Susquehanna

Valleys indicates the most probable location for the axis of the old river channel that can be inferred from a careful analysis of all currently-available records of borings to rock and existing successful wells. This shows how the present channel of the Susquehanna River in its course through Binghamton and Johnson City is nearly 200 feet higher than the old channel and is against the extreme southern side of the valley, where only a relatively thin layer of sediment and till mantles the underlying rock. Elsewhere, down the Susquehanna Valley from Johnson City to Vestal and up the Chenango Valley as far as Chenango Bridge, the present channels do not deviate materially from the inferred location of the old channels.

New small ground-water supplies may still be developed at many other sites on the valley floors, depending upon the distribution of scattered, more or less isolated, gravel beds. Extensive test drilling would be necessary, however, to locate and define these beds accurately. Chances for securing large supplies of ground water should be better within the limits of the old river channels.

A few wells have been drilled into the sedimentary rocks below the surficial beds of clay and gravel but most yield highly-mineralized water. Because of the relative tightness of the rock their yields are low (see records of wells Bm 17, Bm 28, Bm 33, Bm 53, and Bm 54, and table 4, water sample analyses).

The principal potable ground-water supplies of southwestern Broome County occur or originate in a fairly well-localized area. As the underlying sedimentary rocks do not appear to be altered or greatly broken and do not readily transmit ground water, no conduits exist for transporting

ground water from remote areas. Obviously, then, the principal aquifers are the disconnected gravel beds scattered through the material deposited by the rivers along their valley floors. Thus the catchment or drainage areas of the streams in Broome County are evidently as significant to the potential ground-water development as they are to surface-water flow. The principal ground-water divides probably coincide very nearly with topographic divides.

As indicated in a later section of this report, dealing with relation between surface water and ground water, drainage from an area of 228 square miles is potentially available to recharge the gravels and sands in southwestern Broome County. Some of the rainfall on this area finds its way to the water table in the valley bottoms by direct downward percolation through the overburden in areas where little or no clay or silt is present; by inflow into the rims or edges of the overburden where it overlaps the rock slopes of the valleys; and by surface drainage into streams that flow over exposed beds of sand or gravel. Some conception of the disposition of the water-bearing beds may be obtained from the profiles or sectional views shown in figures 3 and 4. Figure 3 gives a sectional view (A-A) along the inferred axis of the old river channel and figure 4 gives two sectional views (B-B and C-C) transverse to the old channel. Wells or borings located near, but not actually on, these sections have been used to obtain a more complete picture.

Examination of section A-A, figure 3, further emphasizes the complex arrangement of the water-bearing sands and gravels. Where data were available the locations of well screens have been shown by means of heavy

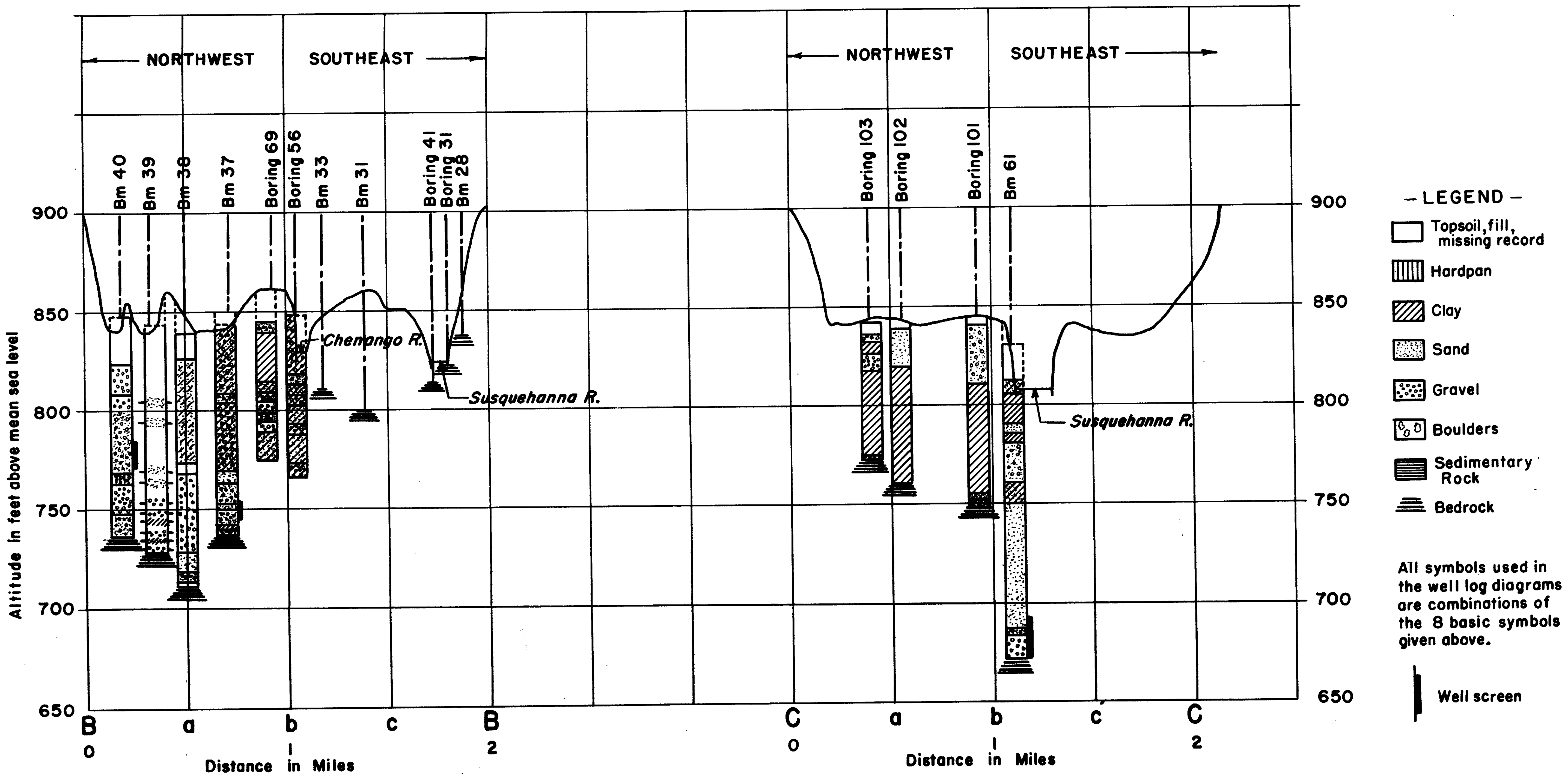
vertical lines adjacent to the appropriate well section. The distribution of screen depths shows that water is drawn from several strata ranging from approximately 50 feet to 130 feet below the land surface. Evidently, with the data now available it is impossible to trace out any one continuous layer or stratum and label it the principal water-bearing zone.

It is significant to note that in nearly every well section clay is present above the water-bearing sands and gravels. This suggests artesian conditions of at least local extent, with no direct local connection between the deeper ground-water bodies and the surface-water bodies.

One feature concerning the drawing of section A-A remains to be considered. If this section line as shown on figure 2 is assumed to approximate the bottom or deepest-lying trace of the old Chenango and Susquehanna Valleys, the logs of wells located to one side of the section line will indicate rock elevations that are too high. Thus if a curve is drawn through the rock elevations shown by section A-A, figure 3, certain sections of the curve will also be too high. A true profile of the rock surface along the true bottom of the valley would be given by a slightly lower curve.

Two transverse sections are drawn in figure 4. Their selection was necessarily limited by the location of existing wells. Neither section is exactly normal to the axis of the old valley. They suggest valley widths slightly greater than the present widths.

Section B-B, traversing the heart of Binghamton, begins on high ground north of the north end of Charles Street, dips down across the low knolls in Spring Forest Cemetery, crosses the Chenango River below the



SECTIONS TRANSVERSE TO VALLEY AXES

FIGURE 4

Ferry Street bridge and the Susquehanna River just below Rockbottom Dam, and ends on high ground again just south of the Susquehanna River. A curve drawn through the rock elevations shown on this section reveals quite clearly that the old rivers skirted the north side of the valley. The section further indicates how rapidly the unconsolidated sedimentary deposits thin out, proceeding from northwest to southeast across the valley, until in the vicinity of Rockbottom Dam they disappear entirely and the present Susquehanna River flows directly over the underlying rock. In fact outcrops of rock may be seen on the south bank of the river.

It is instructive to compare the above section with section C-C, taken diagonally across the valley in the vicinity of the Endwell-Endicott town line. Unfortunately, the only existing wells for which data were available are located north of the Susquehanna River. Although the section is therefore only half complete it suggests a significant change in the shape of the old river valley. If the southeastern half of the profile is approximately an image or reflection of the readily visualized northwestern half of the profile, it may be said that the buried valley at this section is narrow and deep and at a lower elevation than at section B-B where the valley has a relatively broad, shallow outline.

Conditions indicated by the transverse sections described above, however, should be recognized as having only limited, local application. Considerable additional drilling and subsurface exploration will be necessary before the whole story can be told.

The rock elevations shown in figure 2 obviously do not provide adequate coverage to permit contouring the old valley floors. Careful study, however,

of the arrangement of the plotted elevations suggests two rather distinct valley-floor levels. It is noted that the bedrock elevations east of well Bm 56 average about 730 feet above mean sea level, whereas those west of Bm 56 average about 650 feet. Apparently there is a definite break or step between well Bm 56 and Boring 94, indicating two valley-floor levels. The upper, older level underlies the Binghamton and Johnson City areas; the lower, younger level underlies the Endwell, Endicott, and Vestal areas. The longitudinal profile, section A-A, given in figure 3, further illustrates this apparent break in valley-floor levels.

Present slopes of stream beds in the southwestern part of Broome County approximate 2½ feet per mile for the Susquehanna River from the Chenango River to Nanticoke Creek, 8 feet per mile for Nanticoke Creek from the vicinity of (below) Union Center to the Susquehanna River; and 3½ feet per mile for the Chenango River from Fenton to the Susquehanna River. Divergence between the present and the past or preglacial slopes of the Susquehanna River valley is indicated by noting the increasing thickness of the water-bearing sand and gravel beds, proceeding downstream. Comparison of the logs of wells Bm 38 and Bm 65 provides a typical example. Similar comparisons can be made using other pairs of wells.

Between the limits, therefore, of the present valley floors and the buried preglacial valley floors lie the principal aquifers of the southwestern Broome County area.

Water-table fluctuations

Some indication of natural fluctuations of ground-water levels is obtained from records of the Johnson City Water Department, the Ansco

Corporation, and the International Business Machines Corporation. All water-level observations made by these three agencies, however, were made within the cone of depression of one or more pumped wells. Thus some of the natural seasonal variations in ground-water level are either greatly overshadowed or entirely obscured by the variations due to pumpage.

Figure 5 shows total monthly pumpage from the International Business Machines well field and mean monthly water-table fluctuations based on air-line measurements, during pumping, in well Bm 61. As the air-line readings are taken to the nearest pound per square inch the conversions to water level are only accurate to about the nearest 2 feet. In the same figure are also shown the monthly precipitation, as measured by the U. S. Weather Bureau at Binghamton, and the mean monthly discharge of the Susquehanna River at Vestal. Discharge measurements are accurate to within 5 percent and are taken at a station 1.1 miles downstream from the International Business Machines well field. No perennial surface streams enter this 1.1-mile reach of river.

Examination of the various plotted curves leads to several significant observations. A steady increase in average monthly pumpage at the International Business Machines well field, from about 30 million gallons in 1937 to 67 million gallons in 1943, has been reflected in a persistent downward trend in ground-water levels, the decline totaling about 25 feet. Whereas originally all pump impellers in the International Business Machines wells were located 60 feet below the pumphouse pits it was necessary to reset them at a depth of 80 feet in March and April 1944.

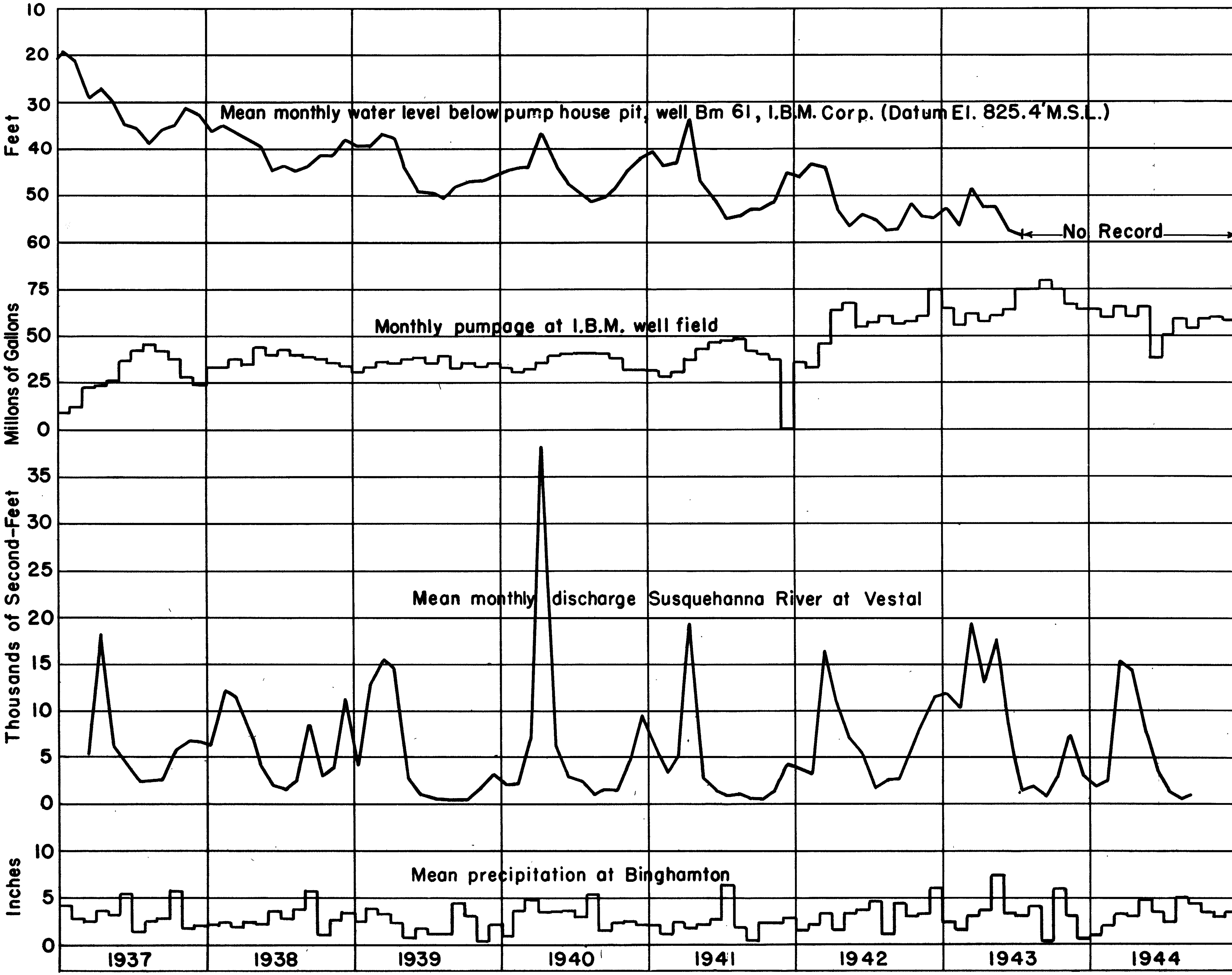


FIGURE 5

GRAPH SHOWING RELATIONS BETWEEN WATER TABLE, PUMPAGE, STREAM FLOW & PRECIPITATION IN VICINITY OF ENDICOTT, N.Y.

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Despite the fact that all water-level observations were made under pumping conditions, some seasonal variations in the water table are quite apparent. Note particularly the sharp rises, leading to yearly highs, that occur each spring in March or April. These are occasioned by the sudden thawing of the ground, permitting the melting snow to percolate downward into the underground reservoirs. Yearly lows occur in July or August when transpiration and evaporation losses are heavy and pumpage is at or just past the maximum.

Figure 6 shows monthly water levels and pumpage at the Ansco Corporation well field and the Johnson City Water Plant well field. Monthly precipitation at Binghamton is given again. Its relation to water levels is greatly obscured by the heavy pumping. Water levels at the Ansco Corporation were measured with a tape in a small-diameter observation well (not described in this report) near the center of the well field. Water levels at the Johnson City Water Plant were measured by an air line in well Bm 51, except for the period October 1938 to December 1941, inclusive. During this period the air line was unserviceable and measurements were made in well Bm 50, using an air line.

Note the general persistent downward trend in water levels at the Ansco field from 1937 through 1942, reflecting a steady increase in the average monthly pumpage; the seasonal rises occurring in the spring; and the lows occurring in the middle or latter part of the summer. The record indicates a total decline in water levels from 1937 through 1942 approximating 15 feet, the increase in average monthly pumpage being from about 68 million gallons to 89 million gallons.

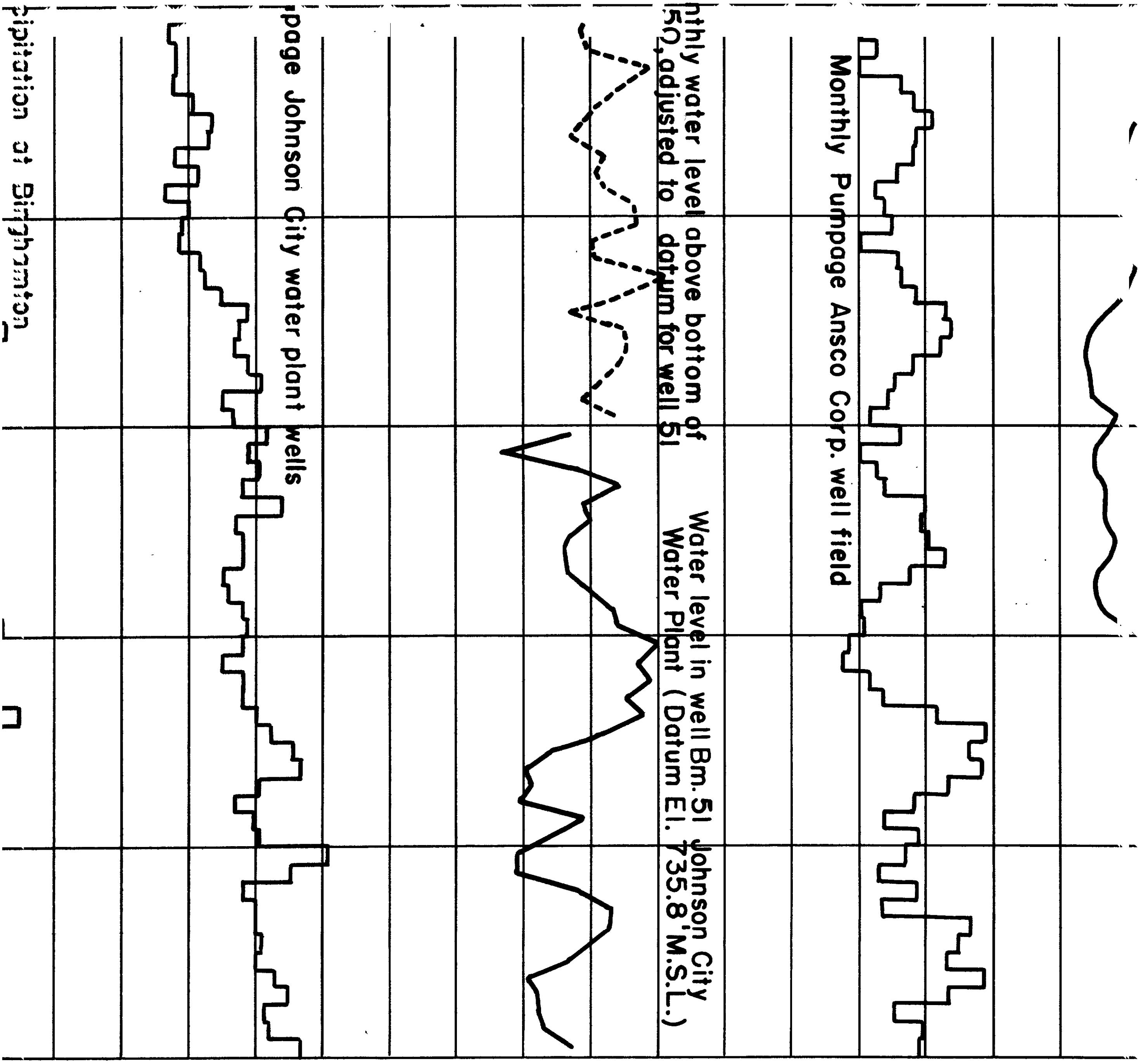

FIGURE 6

GRAPH SHOWING RELATIONS BETWEEN
WATER TABLE, PUMPAGE & PRECIPITATION
IN VICINITY OF
JOHNSON CITY, N.Y.

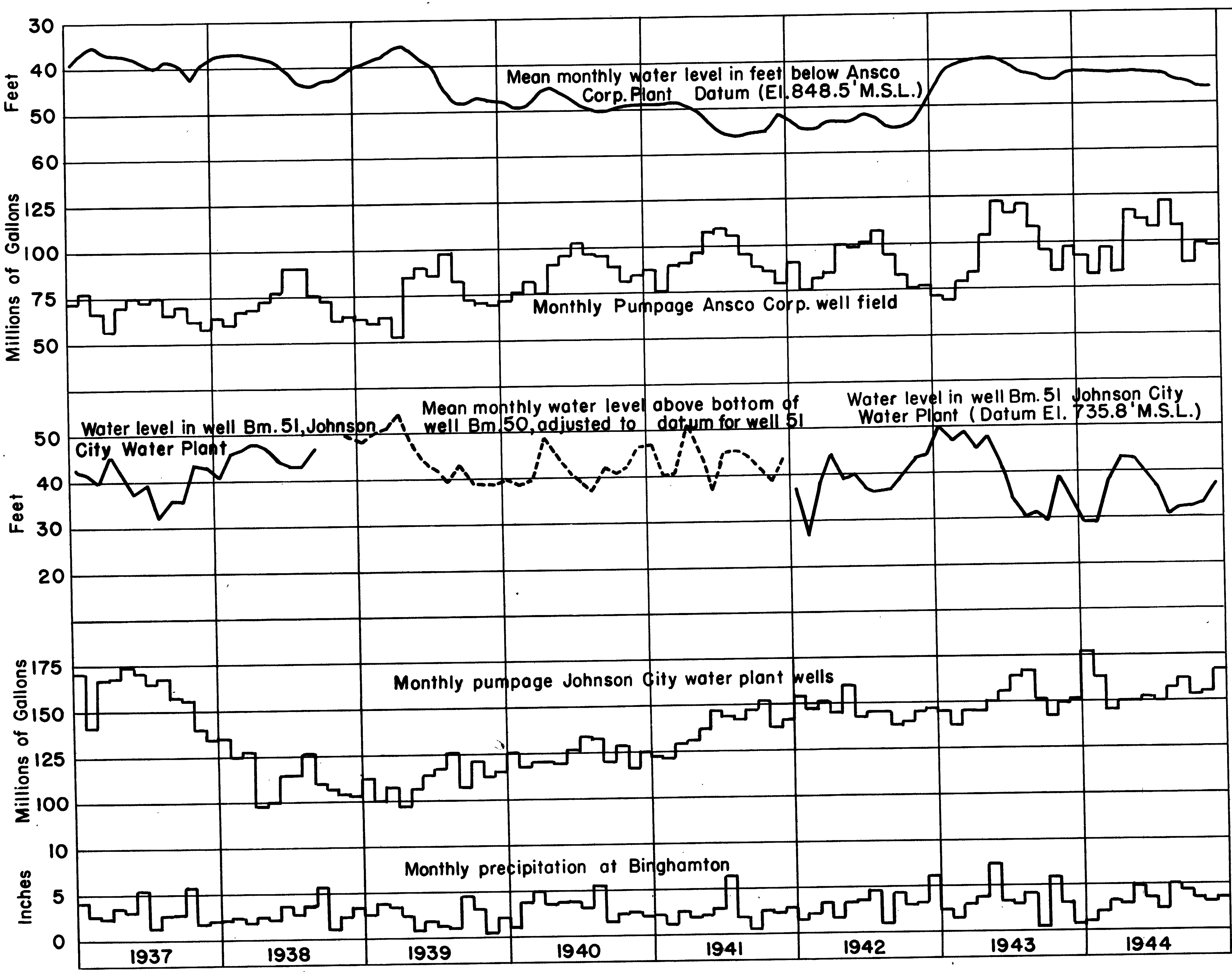

FIGURE 6

GRAPH SHOWING RELATIONS BETWEEN WATER TABLE, PUMPAGE & PRECIPITATION

IN VICINITY OF

JOHNSON CITY, N.Y.

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Relations among water levels, pumpage, and precipitation at the Johnson City field are more obscure, probably due primarily to the fact that observations were made in a pumped well where the lengths of periods of prior operation varied. It is still possible, however, to trace a steady rise in water levels during 1937 and 1938, when pumpage was rapidly decreasing. From 1939 through 1944 the water levels apparently declined slowly in response to a steady increase in average monthly pumpage from about 111 million gallons to 156 million gallons, the net decline totaling approximately 10 feet. The two extremes in seasonal water-table fluctuations are apparent each year throughout the period of record shown.

The fact that water levels have declined with increased pumpage is not of itself alarming, especially when it is realized that the observations have been made near the centers of the several cones of depression. Future detailed area-wide observations will be necessary to determine the extent and shape of these cones of depression and to predict under what circumstances equilibrium conditions may be established.

Development and uses of ground water

Public supplies

In the southwestern part of Broome County approximately 75 percent of the recorded ground-water pumpage is now being used for public supply. It is pertinent, therefore, to describe briefly each of the public-supply systems. All of them, it should be noted (see fig. 2), are located near the apparent center of the old glacial valley.

The village of Hillcrest derives its water supply from two wells, Bm 14 and 15, located 67 feet apart on the east side of the present Chenango Valley bottom. Logs and descriptions of these wells are given in the section of this report, on records of wells, and a description of the quality of the water may be found in table 4. Computations of the transmissibility and permeability of the aquifer tapped by these wells are given under "Quantitative observations". Pumpage figures are recorded in table 1.

The city of Binghamton obtains about 90 percent of its water supply from the Susquehanna River but the remaining 10 percent is pumped from a gravel-packed well, Bm 26, located near the east bank of the Chenango River in the so-called Stowe Flats area. The log and description of the well is given in the section on record of wells, a water analysis is given in table 4, and pumpage figures are recorded in table 1. Daily pumpage from the well averages about 800,000 gallons. The well is equipped with a zeolite softener and the entire installation operates automatically, pumping the softened water directly into the distribution system.

One of the largest municipal ground-water supplies in the area is that developed by the village of Johnson City. Three Kellytype wells, Bm 50, Bm 51, and Bm 52 located, as shown by figure 7, on the north bank of the Susquehanna River, supply the industrial and domestic needs of a village of more than 18,000 people, as well as the adjacent communities of Westover, Fairmont, Oakdale, and Prospect Terrace. The pumping is usually arranged so that at any one time only two of the three wells are in operation. This permits some rotation of the water demand but the

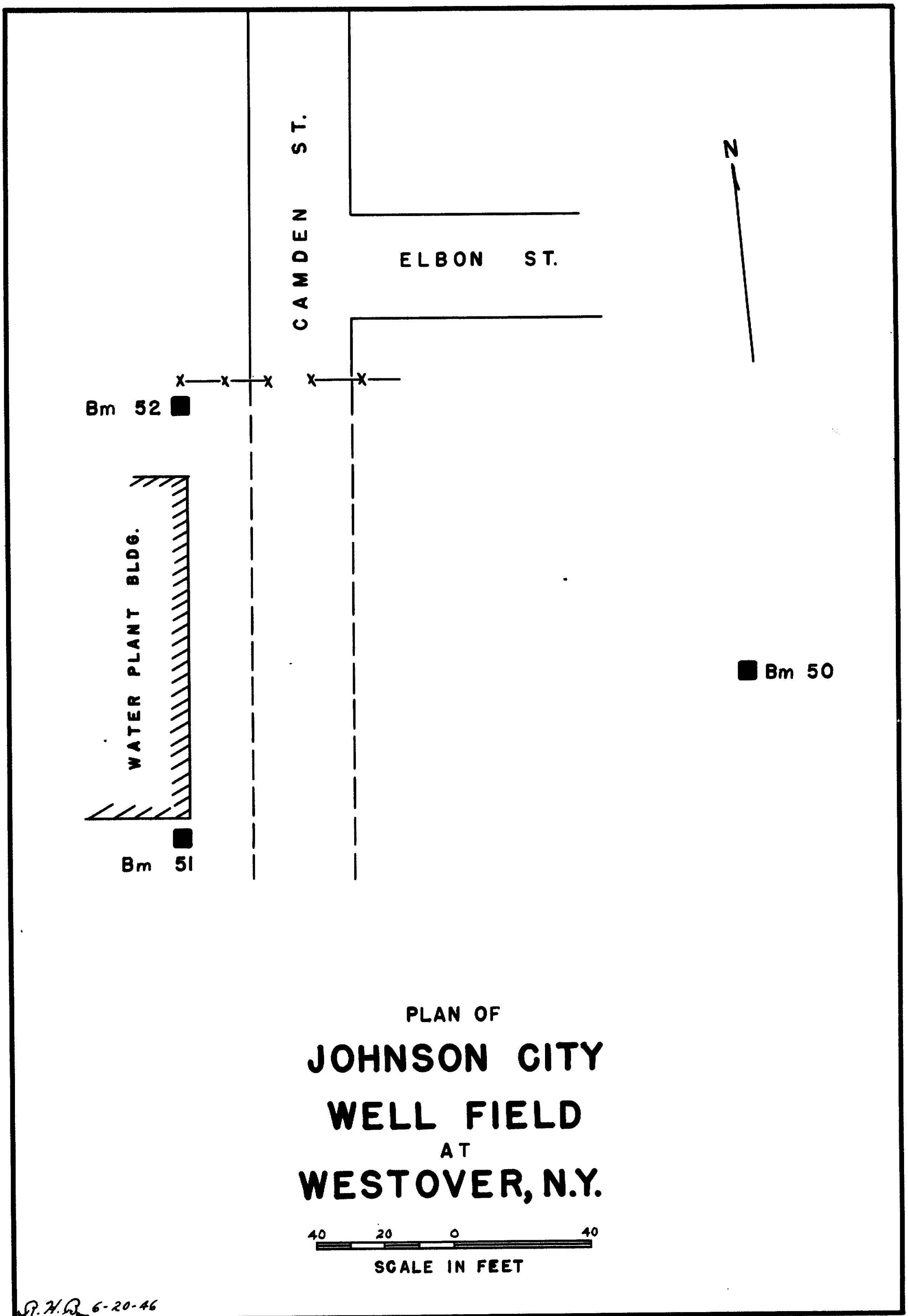

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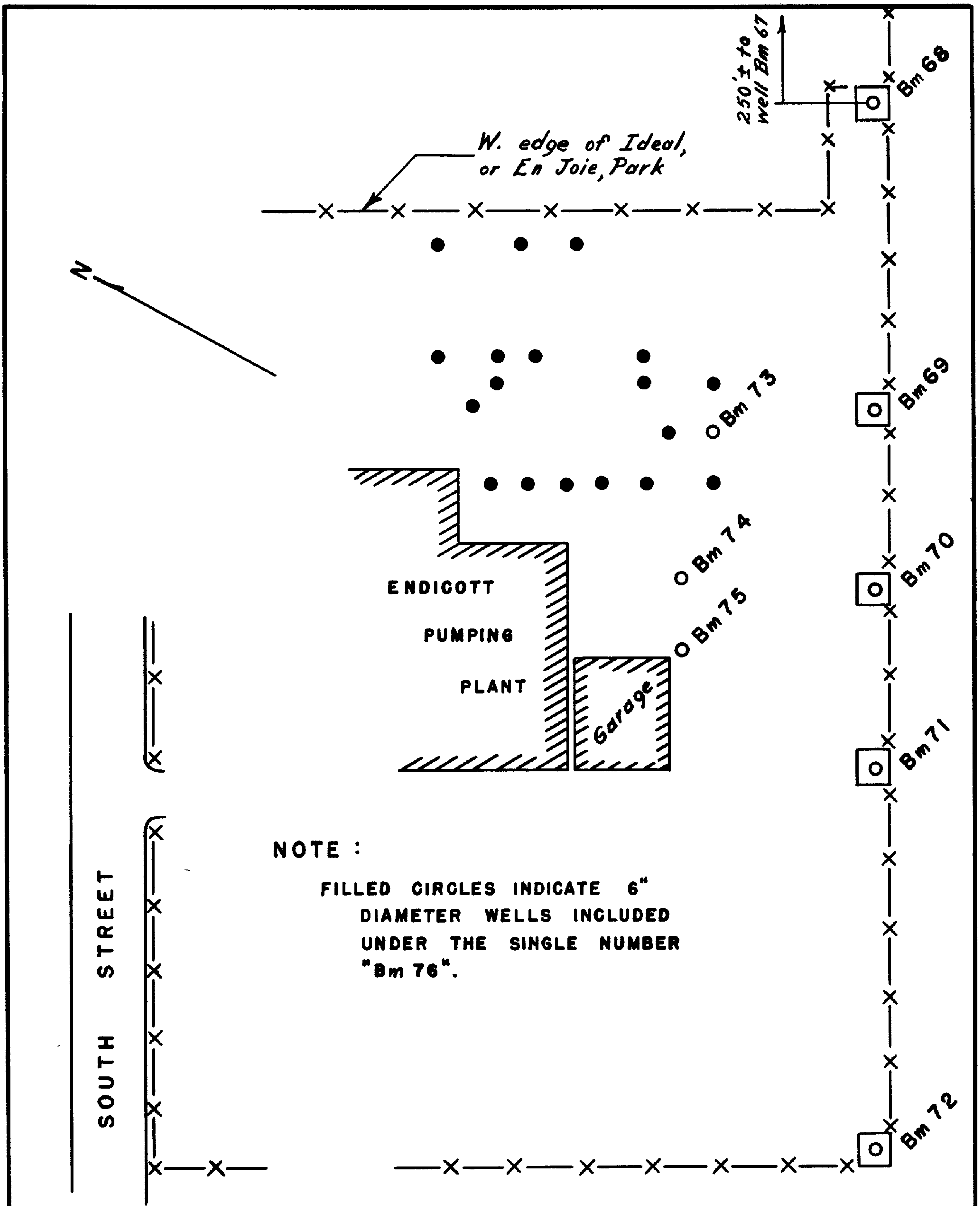
FIGURE 7

principal benefits are of a mechanical and operational nature rather than hydraulic. The wells are located within an area so small that they interfere with each other. Probably the minimum distance between wells of any pair here should be about 1,000 feet instead of 125 feet to reduce interference. For additional data on these wells reference should be made to the section on records of wells, to table 1, and to table 4, giving well logs and descriptions, pumpage figures, and water analyses, respectively. The daily pumpage averages more than 5 million gallons. The water is chlorinated at the wells before being pumped into the distribution system.

The village of Endicott develops a ground-water supply for the industrial and domestic needs of more than 20,000 people, and supplies the adjacent communities of West Endicott, Endwell, and Vestal. The principal part of this supply is pumped from a well field located, as shown in figure 8, on the north bank of the Susquehanna River, and comprising 26 wells averaging about 150 feet in depth. As indicated by the sketch the well field occupies an area approximately 120 feet by 280 feet, and 24 of the wells are concentrated in the eastern half of the field. Obviously, then, there is considerable interference among the wells and no single well can be operated at the maximum yield of which it would be capable if it were the only well in the area. In addition to the above-described well field four other wells, Bm 58, Bm 66, Bm 67, and Bm 78, located at separate sites around the Endicott-Endwell area, furnish the balance of the total supply required. Detailed locations and several well logs are given in the section on records of wells, and tables 1 and 4 give pumpage figures and water analyses. The daily pumpage averages more than 9 million gallons.



PLAN OF

ENDICOTT WELL FIELD

AT

ENDICOTT, N.Y.

40 20 0 40

SCALE IN FEET

G.H.G. 6-21-46

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FIGURE 8

The water is chlorinated at the well field pumping station and at the individual pump houses before delivery to the distribution system.

Industrial supplies

Supplies for two of the principal industrial users of ground water were investigated and pertinent data regarding their installations are presented below.

The Ansco Corporation, whose plants are in the northwestern part of Binghamton, obtains the water required in its manufacturing processes from a field of five wells located as shown by figure 9. The average depth of the wells is about 100 feet. The distance between any two wells is not great enough to prevent mutual interference. The cone of depression created by operation of the wells is apparently elongated in an east-west direction, as the hills rising from the valley floor about 1,000 feet north of the field restrict the full development of the cone in that direction. One additional well, Bm 38, located about 2,100 feet east of the field and not shown on the location sketch, is used as part of the Ansco supply. Details of the wells and their logs are given in the section on records of wells, and pumpage and water-analysis data appear in tables 1 and 4. The daily pumpage averages more than 3 million gallons.

The International Business Machines Corporation, whose plant is in the eastern section of Endicott, utilizes a field of four wells to provide the water required in its industrial processes. Figure 10 indicates the location of the well field, on the north bank of the Susquehanna River, and the arrangement of the wells. Again, however, the spacing between wells is too small to prevent interference. The section on records of wells

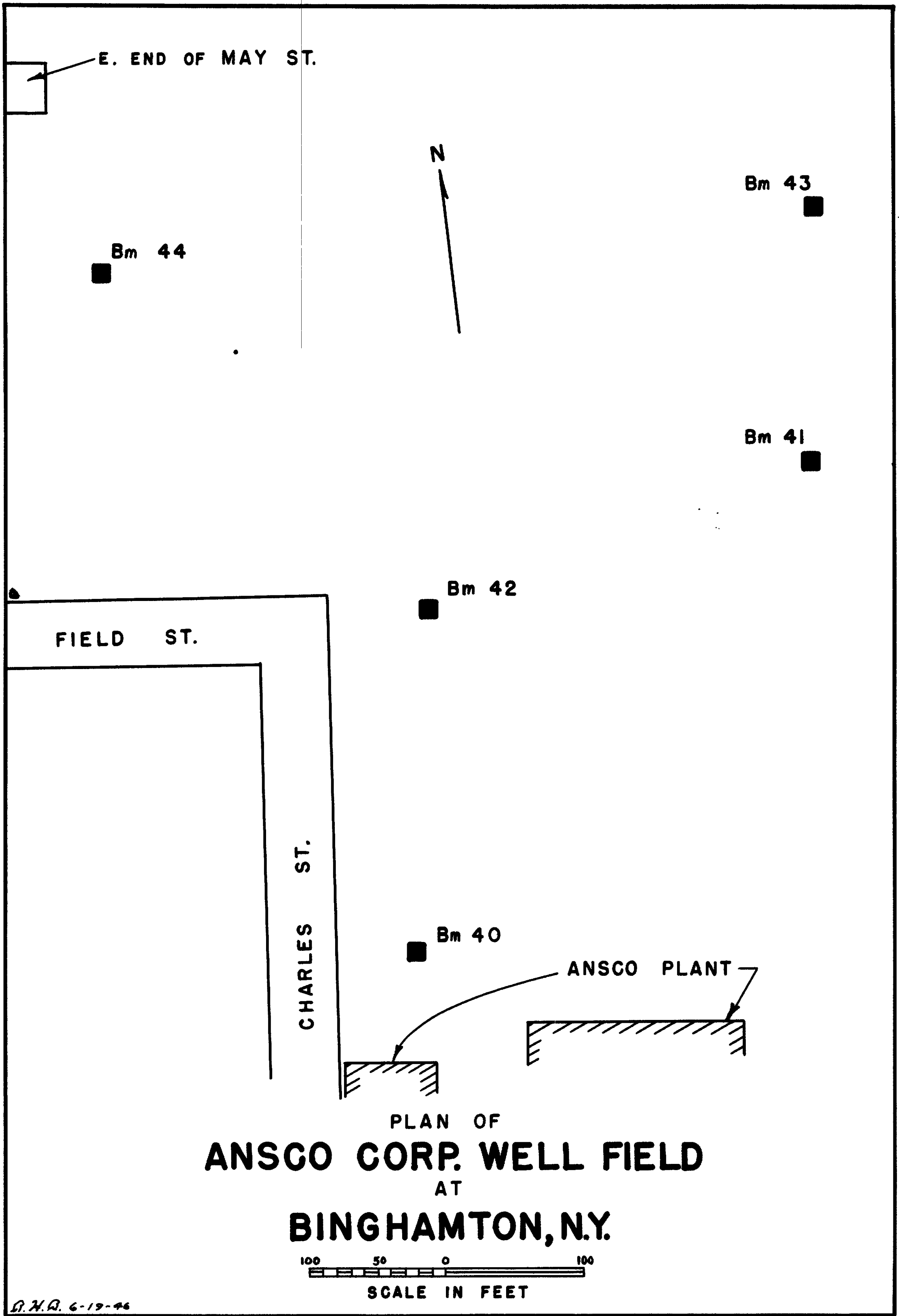

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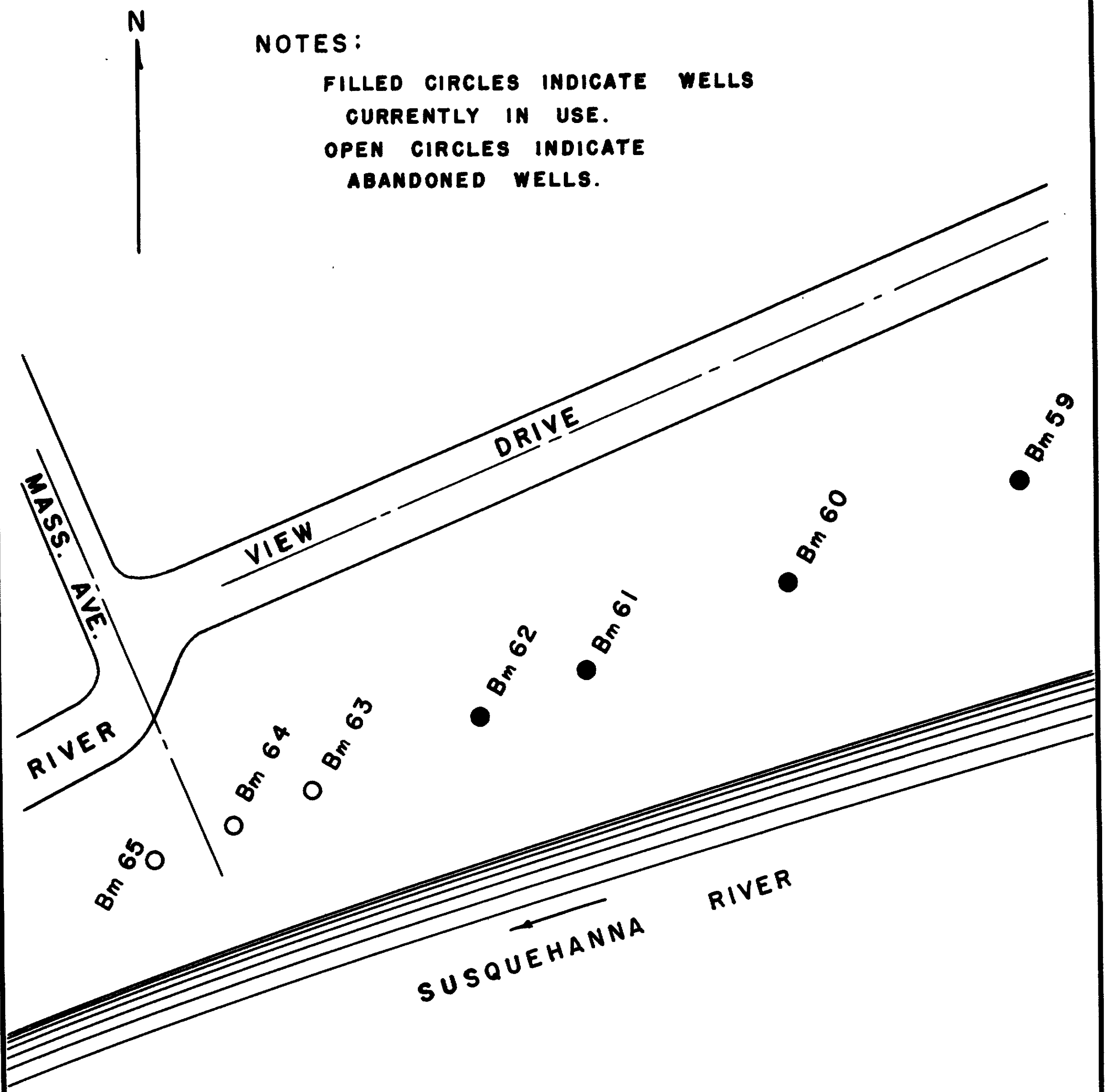
FIGURE 9

describes the wells and gives the available logs. Tables 1 and 4 contain pertinent pumpage data and data on quality of water. The daily pumpage averages nearly 2 million gallons.

In addition to the foregoing supplies, there are many small separate supplies having a semi-industrial application in the air-conditioning field. A few of the many wells in the area known to be used for this purpose are described in this report. Reference should be made to wells Bm 31, Bm 33, and Bm 37 in the section on records of wells.

Private supplies

Beyond the present economical reach of city mains are to be found numerous small private ground-water supplies. Many of these supplies are derived from wells drilled through relatively shallow unconsolidated materials into rock, for the areas outside the zones served by the city or village systems are often on higher land, above the valley floor, where the depth to rock is not great. Records of wells Bm 6, Bm 12, Bm 17, Bm 21, Bm 22, Bm 24, Bm 79, and Bm 83, given in this report, are typical of the private supplies investigated. Numerous others scattered over the entire southwestern part of Broome County remain to be canvassed.



PLAN OF

INTERNATIONAL BUSINESS MACHINES CORP. WELL FIELD

AT

ENDWELL, N.Y.

100 50 0 100

SCALE IN FEET

R.H.B. 6-21-46

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FIGURE 10

Table 1. Monthly Pumpage of Ground Water, in Millions of Gallons, from the Principal Industrial and Public Well Fields

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Well a/ Field	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Total
					1	9	3	7					
Ansco	72.3	76.9	66.7	57.0	69.5	75.0	72.9	75.1	66.0	70.1	61.8	57.4	820.7
Johnson City	171.3	141.5	167.6	168.0	174.6	171.4	164.4	168.0	157.3	156.1	139.3	134.2	1913.7
IBM	9.3	12.6	23.2	24.0	26.4	37.2	42.8	46.2	42.3	37.8	33.0	24.2	359.0
Endicott	194.6	205.8	237.2	194.4	174.5	222.0	201.4	211.1	154.6	185.2	165.2	150.8	2296.8
					1	9	3	8					
Ansco	64.2	60.3	67.4	67.8	73.2	76.6	91.5	91.2	76.5	73.0	61.8	63.7	867.2
Johnson City	135.4	124.4	127.8	98.3	99.9	113.8	114.3	126.6	109.5	106.6	103.7	102.6	1362.9
IBM	33.5	33.0	37.8	34.2	43.7	39.6	42.8	40.0	38.7	37.8	35.1	33.8	450.0
Endicott	160.4	174.9	166.9	152.6	158.1	206.0	180.4	238.1	181.5	181.6	212.4	165.4	2178.3
					1	9	3	9					
Ansco	63.0	60.3	63.6	52.5	85.3	90.0	85.9	97.7	82.5	72.6	71.2	69.3	893.9
Johnson City	112.5	99.8	107.2	97.0	106.7	113.8	117.3	126.1	107.2	121.3	113.4	115.5	1337.8
IBM	31.6	33.0	36.6	35.7	37.8	38.1	35.0	39.0	32.7	35.0	33.6	35.0	423.1
Endicott	179.6	175.9	230.6	167.1	210.7	188.8	214.6	253.2	181.1	171.0	227.9	164.3	2364.8

Table 1-continued

Well a/ Field	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Total
					1	9	4	0					
Ansco	71.6	76.2	81.9	74.6	91.6	96.4	102.4	96.8	95.9	89.5	81.6	84.4	1042.9
Johnson City	126.2	117.8	120.6	120.4	118.9	127.0	134.0	133.3	119.7	129.0	116.3	125.3	1488.5
IBM	33.0	31.0	32.7	35.2	38.7	39.9	41.4	41.4	39.7	38.1	31.9	32.1	435.1
Endicott	192.9	187.3	171.5	199.2	180.3	195.5	202.2	207.0	205.9	187.5	206.9	224.4	2360.6
					1	9	4	1					
Binghamton						b/ 10.2	29.9	30.9	30.2	30.6	30.1	31.4	193.3
Ansco	87.5	75.7	89.9	91.2	96.6	108.3	109.2	106.4	95.4	88.5	85.7	78.9	1113.3
Johnson City	123.5	122.1	129.2	131.6	137.4	147.4	144.4	142.8	147.4	152.6	138.4	142.3	1659.1
IBM	31.6	28.4	30.5	37.1	43.3	46.7	48.2	48.6	41.9	40.2	37.0	0.3	433.8
Endicott	222.2	205.9	206.7	202.8	212.5	244.0	245.8	257.3	271.9	257.3	252.9	288.9	2868.2
					1	9	4	2					
Binghamton	30.7	27.7	28.2	16.7	---	---	---	---	---	---	---	---	103.3
Ansco	90.8	76.3	82.6	84.5	100.0	98.4	101.6	107.2	93.9	83.3	75.7	77.8	1072.1
Johnson City	154.8	146.8	152.0	144.8	159.7	143.2	146.2	145.9	137.7	140.1	146.0	147.2	1764.4
IBM	35.7	33.2	45.5	63.9	68.2	55.1	57.2	59.7	57.0	58.1	60.6	74.8	669.0
Endicott	269.9	291.8	282.9	288.8	289.4	296.6	276.6	320.6	222.5	260.7	261.8	270.5	3332.1

Table 1--continued

Well a/ Field	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Annual Total
					1	9	4	3					
Hillcrest	4.1 c/	4.3	4.3	4.2	4.8	5.2	6.5	6.1	6.2	6.4	5.3	4.1	61.5
Binghamton	---	---	6.5	31.1	31.5	30.1	30.0	27.5	2.8	9.3	10.2	31.6	210.6
Ansco	71.8	69.3	79.4	83.8	104.3	122.7	116.4	121.6	107.9	96.1	84.2	97.5	1155.0
Johnson City	144.9	137.1	146.0	145.0	151.2	156.4	164.2	167.1	150.6	142.1	149.3	152.2	1806.1
IBM	65.4	56.6	62.2	58.1	61.5	64.4	75.4	75.9	78.9	75.6	67.8	63.9	805.7
Endicott	295.5	282.6	268.0	279.3	267.5	285.1	289.1	285.6	286.1	260.1	256.9	263.4	3319.2
					1	9	4	4					
Hillcrest	4.5	4.9	5.0	4.7	5.7	5.0	5.3	6.1	6.8	4.4	3.7	3.7	59.8
Binghamton	30.9	29.0	10.6	---	14.0	27.5	30.2	29.5	30.0	30.9	25.8	31.2	289.6
Ansco	92.8	82.6	97.5	84.3	117.0	112.3	108.0	122.6	108.7	88.1	98.8	98.4	1211.1
Johnson City	177.1	163.2	145.2	149.1	148.9	151.8	148.9	157.3	162.6	153.0	154.0	167.2	1878.3
IBM	64.0	59.4	66.1	61.1	65.9	38.4	51.4	58.6	54.0	58.8	59.9	58.3	695.9
Endicott	289.7	291.5	271.1	281.1	307.3	276.7	289.0	292.7	297.0	304.0	303.5	293.1	3496.7

a/ Wells pumped in each field are as follows:

Hillcrest........................Bm 14 and 15.
Binghamton.......................Bm 26.
Ansco............................Bm 38, and 40-44 incl.
Johnson City.....................Bm 50, 51 and 52.
Internat'l Bus. Mach.............Bm 59-62 incl.
Endicott.........................Bm 58, 66-76 incl. and 78.

b/ Well operation begins.

c/ Previous record of pumping not available.

Quantitative observations

Permeability

Although no controlled quantitative tests have yet been made on the aquifers in the southwestern part of Broome County, an indication of the permeability to be expected when such tests are possible is obtained from observations made on a test well (Bm 16) during a period of pumping from one of the Village of Hillcrest supply wells (Bm 14) located approximately 50 feet away, after it had been shut down for over 8 hours. The rate of pumpage was not measured but was estimated to be 200 gpm. The following table summarizes the data collected:

Observations made on well Bm 16, July 10, 1945

Hour	Time t minutes	Depth to water feet	Drawdown s feet	Remarks
8:40 p.m.		16.38	--	Static level, July 10, 1945.
8:44	--	--	0.00	Pumping Begins in Well Bm 14
8:46	2	16.90	0.52	
8:48	4	17.35	0.97	
8:49	5	17.41	1.03	
8:50	6	17.45	1.07	
8:51	7	17.48	1.10	
8:52	8	17.50	1.12	
8:52½	8.5	17.52	1.14	
8:54	10	17.55	1.17	
8:55	11	17.57	1.19	
8:57½	13.5	17.61	1.23	
9:00	16	17.64	1.26	
9:02	18	17.68	1.30	
9:04	20	17.70	1.32	
9:06	22	17.71	1.33	
9:09	25	17.73	1.35	
9:13	29	17.76	1.38	
9:15	31	17.77	1.39	
9:20	36	17.80	1.42	
9:22	38	17.80	1.42	
9:26	42	17.82	1.44	
9:31½	47.5	17.84	1.46	
9:38	54	17.85	1.47	
9:50	66	17.86	1.48	Final observation

To make use of these data a formula developed by Theis and discussed in a paper by Wenzel[13/] is employed. This gives the drawdown in the vicinity of a discharging well in terms of the discharge of the well and the coefficients of transmissibility and storage of the aquifer. The coefficient of transmissibility of the aquifer is defined as discharge per unit width of the aquifer (measured normal to the direction of flow) per unit hydraulic gradient. As used by the Geological Survey the coefficient of transmissibility is commonly expressed in gallons per day per foot. The coefficient of storage is defined as the volume of water that a unit decline of head releases from storage in a vertical prism of the aquifer of unit cross-section. It is expressed as a decimal fraction. The definition of the coefficient of permeability introduces the idea of discharge of the aquifer per unit area instead of per unit width. As used by the Geological Survey the coefficient of permeability is commonly expressed in gallons per day per square foot.

The basic formula developed by Theis for determining these coefficients is written

$$s = \frac{Q}{4\pi T} \int_{\frac{r^2 S}{4Tt}}^{\infty} \frac{e^{-u}}{u}\, du \quad \ldots\ldots\ldots\ldots \quad (1)$$

where $u = \dfrac{r^2 S}{4Tt}$

and
r = distance from the pumping well
t = time elapsed since start of pumping
T = transmissibility of the aquifer
S = coefficient of storage of the aquifer
Q = discharge of the pumping well

13/ Wenzel, L. K., Methods for determining permeability of water bearing materials: U. S. Geol. Survey Water-Supply Paper 887, pp. 87-89, 1942.

Integration of equation (1) and substitution of limits gives

$$s = \frac{Q}{4\pi T}\left[-0.577 - \log_e u + u - \frac{u^2}{2.2}\ \frac{u^3}{3.3}\ \ldots\ldots\ldots\right] \quad (2)$$

For large values of t, however, u becomes quite small so that only the first two terms in the right hand side of equation (2) need be considered. Thus

$$s = \frac{Q}{4\pi T}\left[\log_e\left(\frac{1}{u}\right) - 0.577\right] \ldots\ldots\ldots\ldots\ldots \quad (3)$$

$$\text{or } s = \frac{Q}{4\pi T}\left[\log_e\left(\frac{4Tt}{r^2S}\right) - 0.577\right] \ldots\ldots\ldots\ldots \quad (4)$$

But $\log_e e^{0.577} = 0.577$

and $e^{0.577} = 1.781$

Thus by substituting in equation (4)

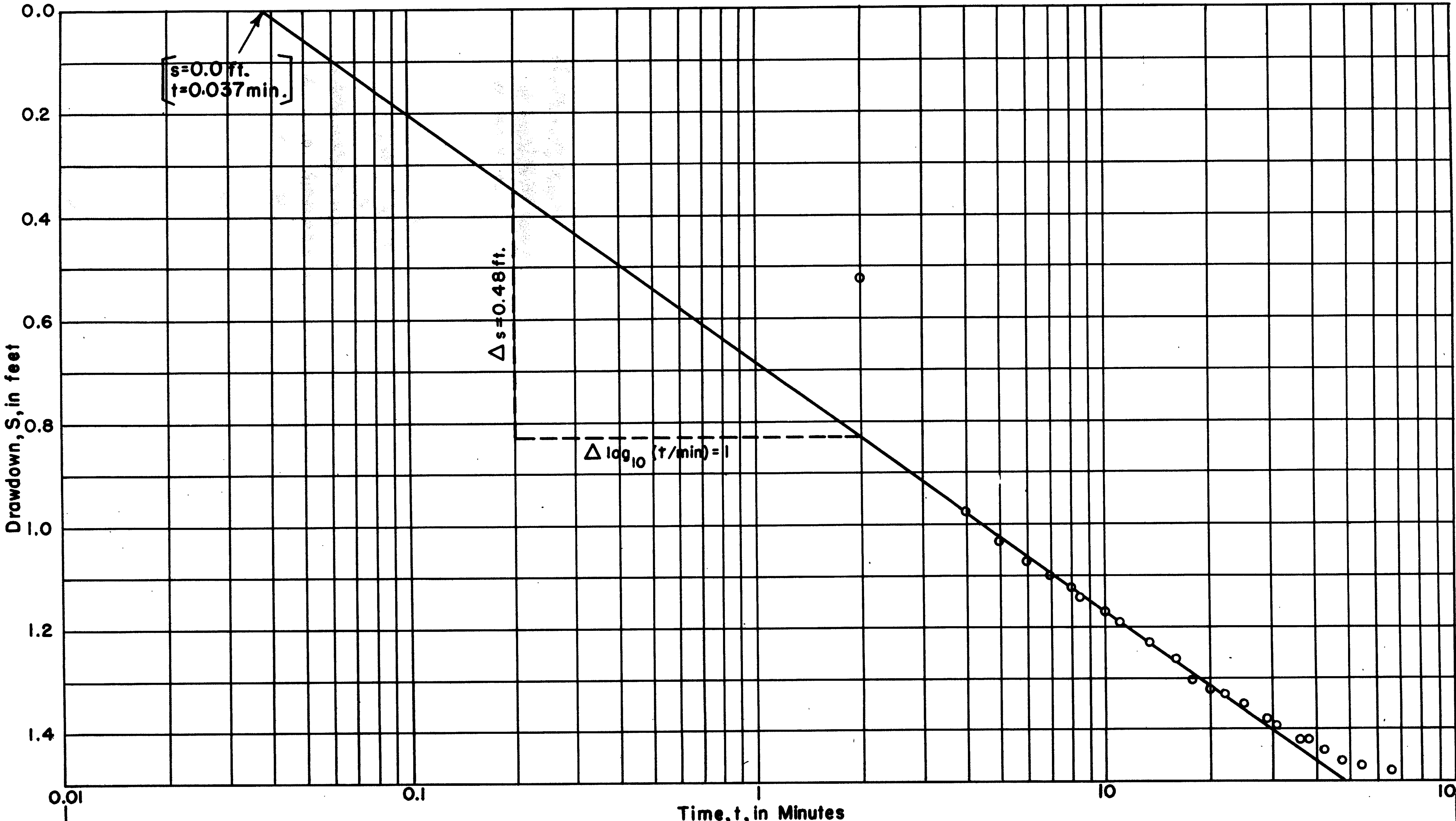
$$s = \frac{Q}{4\pi T}\left[\log_e \frac{4Tt}{r^2Se^{0.577}}\right] \ldots\ldots\ldots\ldots\ldots \quad (5)$$

and because $\log_e N = 2.30 \log_{10} N$

$$s = \frac{2.30\ Q}{4\pi T}\left[\log_{10} \frac{2.25Tt}{r^2S}\right] \ldots\ldots\ldots\ldots\ldots \quad (6)$$

If r is held constant then equation (6) will give the relation between drawdown and time at a fixed distance from the pumping well. This is the equation of a straight line where the drawdown s is plotted against the log of time t.

The data collected during the Hillcrest pumping test are plotted in figure 11, in the manner just suggested, and a straight line is drawn through the plotted points.



SEMILOGARITHMIC PLOTTING OF DATA FOR PUMPING TEST

AT

HILLCREST, NEW YORK

FIGURE 11

The decrease in the rate of drawdown toward the end of the test, indicated by the progressive divergence from the straight line of the last few points plotted, suggests that the aquifer is connected with the river. The exact determination of the reach of river supplying the aquifer would require two or three observation wells instead of the single observation well used in this test.

If equation (6) is re-written to show the change in drawdown, Δs, occurring between time t_2 and time t_1, where $t_2 > t_1$ then

$$\Delta s = \frac{2.30\ Q}{4\pi T}\left[\log_{10}\ \frac{t_2}{t_1}\right] \quad \ldots\ldots\ldots\ldots\ (7)$$

Equation (7) can be further simplified by selecting the times t_2 and t_1 so that they occur just one log cycle apart.

Then, $\log_{10}\ \frac{t_2}{t_1} = 1$, and

$$\Delta s = \frac{2.30\ Q}{4\pi T} \quad \ldots\ldots\ldots\ldots\ (8)$$

This provides a ready means for determining the coefficient of transmissibility T, since from equation (8)

$$T = \frac{2.30\ Q}{4\pi\ \Delta s} \quad \ldots\ldots\ldots\ldots\ (9)$$

In figure 11 the straight line shows a change in drawdown, Δs, of 0.48 foot in one log cycle of time. With Q = 200 gpm, or 288,000 gpd, substitution in equation (9) gives

$$T = \frac{2.30 \times 288{,}000\ \text{gpd}}{4\pi \times 0.48\ \text{ft}} = 110{,}000\ \text{gpd per ft}$$

The coefficient of storage S may be determined by letting the drawdown s in equation (6) equal zero. Then

$$\log_{10} \frac{2.25Tt}{r^2S} = 0 \quad \ldots\ldots\ldots\ldots\ldots \quad (10)$$

$$\text{or} \quad \frac{2.25Tt}{r^2S} = 1 \quad \ldots\ldots\ldots\ldots\ldots \quad (11)$$

$$\text{and} \quad S = \frac{2.25\ Tt}{r^2} \quad \ldots\ldots\ldots\ldots \quad (12)$$

In figure 11 the straight line intersects the zero-drawdown line at time t = 0.037 min. Using r = 50 ft, T = 110,000 gpd per ft or 10.2 cfm per ft, and substituting in equation (12) gives

$$S = \frac{2.25 \times 10.2 \times 0.037}{50 \times 50} = 0.00034$$

The low order of magnitude of this coefficient indicates artesian conditions.

If, as indicated by the log of well Bm 14, the average thickness m of the aquifer in the vicinity is approximately 50 feet, the coefficient of permeability P may be computed as

$$P = \frac{T}{m} = \frac{110{,}000 \text{ gpd/ft}}{50 \text{ ft}} = 2{,}200 \text{ gpd per sq ft}$$

These values for T and P are within the ordinary range for sand and gravel aquifers.[14] However, they should not be interpreted strictly as indicative of the maximum rate at which water can be withdrawn from the entire width and depth of the glacial valley. The values given above refer only

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14/ Wenzel, L. K., op. cit., p. 13 (see footnote 13).

to one stratum of the many water-bearing strata in the valley. As indicated previously in this report, additional test drilling and further quantitative studies will be necessary to define precisely the location, extent, and permeability of the many water-bearing sands and gravels.

Specific capacity

Meinzer[15] defines the specific capacity of a well as its rate of discharge per unit of drawdown. For wells of the same diameter comparison of the specific capacities will indicate, to a limited extent, the relative abilities of the various aquifers to deliver water. The following tabulation of the specific capacities of selected wells in the southwestern part of Broome County permits such comparisons to be made. For convenience the wells used in this tabulation are grouped in numerical order according to casing diameter and to the aquifers penetrated.

Well No.	Diameter inches	Draw-down feet	Discharge gpm	Specific capacity gpm/ft
(Wells in rock)				
Bm 6	5	4.5	10	2.2
28	8	188	65	0.3
37	8	15.5	50	3.2
53	8	78	90	1.2
(Wells in unconsolidated deposits)				
Bm40	12	10	250	25
41	12	15	200	13
43	12	12	150	13
62	12	7	750	107
26	16	12	677	73
42	16	4	1,200	300
61	16	21	950	45
44	18	7	1,800	257
47	18	4	500	125
49	18	6	500	83
48	25	7.5	615	82
51	25	2	2,180	1,090
52	25	8	2,200	275
58	25	11	1,500	136

15/ Meinzer, O. E., Outline of ground-water hydrology: U. S. Geol. Survey Water-Supply Paper 494, p. 62, 1923.

Note the large difference between the specific capacities of wells in rock and those of wells in the unconsolidated glacial deposits. The range in specific capacities for wells of the same diameter must be attributed in part to constructional differences, such as screen lengths, size of screen openings, and kind and extent of development. The rest of the range can be properly attributed to variations in the permeability and thickness of the glacial deposits from place to place in the valley. Examination of the well logs and of the sections given in figures 3 and 4 suggests some of the variation that can be expected in the thickness and character of the water-bearing materials throughout the area.

Temperature

Ground water in the southwestern part of Broome County has an average temperature of about 50° F. The average mean annual air temperature is 47.5° F. Single measurements of ground-water temperature for nine wells in the area are tabulated below but the possible variation in temperature, during the seasons of the year, in any given well has not yet been determined.

Table 2. Temperature of ground water in southwestern Broome County

Well No.	Temp. in °F.	Well No.	Temp. in °F.	Well No.	Temp. in °F.
Bm 28	50	Bm 37	51	Bm 54	50+
29	50	38	51	55	50±
33	51 - 52	53	48	62	51-

Because of the relatively low temperature, numerous small installations utilize ground water for cooling and air-conditioning purposes;

Relation to Surface Water

As indicated in the sections on occurrence of ground water and on water-table fluctuations, there is no significant local relation between surface water and ground water. Substantial changes in stream flow can occur with little corresponding change in ground-water levels. In fact, opposite changes have been noted (see fig. 5). The fact that flood flows in streams coincide with sharp water-table rises, however, does not contradict the statement made above. Rather it indicates the mutual dependency of surface water and ground water upon such areal or watershed factors as temperature, precipitation, and snow cover. The same spring conditions that create flood flows in the surface streams release large amounts of water for immediate storage underground and, in fact, a point is soon reached where surface streams are receiving both the part of the melting snow that escapes directly as runoff, and a large amount of ground water from the nearly-filled underground reservoirs.

Fortunately, for the purpose of this report, three stream gaging stations operated by the Surface Water Division of the Geological Survey, in cooperation with the N. Y. State Department of Public Works, are ideally located for measuring surface inflow to the outflow from the southwestern part of Broome County. Thus it is possible to make at least a qualitative approach, supported by considerable quantitative data, to the study of relations between ground-water storage and use and surface runoff. The gaging stations used are located on the Chenango River near Chenango Forks and the Susquehanna River at Conklin and Vestal. Locations of these stations are shown in figure 2. By subtracting from the drainage area for the

Vestal station the sum of the areas for the stations at Conklin and Chenango Forks a value of 228 square miles is obtained, representing the intervening drainage area that covers more than 50 percent of the area designated in this report as the southwestern part of Broome County. Fortunately again, the area covered is that in which the heaviest ground-water developments to date have occurred. Drainage boundaries of the area have been drawn in figure 2.

In table 3 some of the quantitative data showing relations between surface water and ground water have been assembled by calendar years for the period March 3, 1937, to September 30, 1944, inclusive. The table with its accompanying descriptive notes is very nearly self-explanatory. Some of its limitations and implications should be pointed out, however. Stream-flow records, for example, are accurate to within 5 percent and the estimated accuracy of ground-water pumpage records, for the supplies investigated, is within this same percentage.

In computing theoretical runoff the assumption that the precipitation records obtained at Binghamton are applicable over all the 228 square miles of watershed admittedly gives errors. They should be on the conservative side, however, since it was previously shown, in the discussion on climate, that the annual precipitation for Binghamton is generally as low as, or lower than, most of the surrounding sections of the State. Thus if more detailed coverage of the precipitation over the watershed were available the theoretical runoff would perhaps be greater than the values shown in this table, thereby increasing the theoretical quantities of water available for ground-water storage.

Table 3. Yearly Data on Precipitation, Runoff, Evaporation and Pumpage in Southwestern Broome County.

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Year	Annual Precip. in Inches at Binghamton	Mean Daily Discharge, in Second-Feet at:			Mean Daily Runoff in Second-Feet (Drainage Area 228 Sq. Mi.) a/		Theoretical Mean Daily GW Storage, in Millions of Gallons d/	Annual Evaporation from Ground, in Inches of Water e/	Adjusted Mean Daily GW Storage, in Millions of Gallons f/	Mean Daily Ground Water Withdrawal in Millions of Gallons g/
		Vestal (Drainage Area 3960 Sq. Mi.)	Conklin (Drainage Area 2240 Sq. Mi.)	Chenango Forks (Drainage Area 1492 Sq. Mi.)	Actual b/	Theoretical c/				
1937 h/	31.27	6047	3236	2460	351	525	112	12.3	68	14.7
1938	33.69	6193	3612	2280	301	566	171	13.9	100	13.4
1939	27.38	4781	2713	1815	253	460	134	10.5	82	13.8
1940	37.59	6581	3612	2649	320	630	195	13.3	126	14.6
1941	29.43	3956	2141	1613	202	495	189	12.2	111	17.2
1942	38.20	6693	3853	2518	322	642	207	14.0	131	19.0
1943	39.16	8210	4560	3239	411	658	160	14.7	100	20.2
k/ 1944	29.10	5577	2983	2291	303	488	120	12.7	67	20.9

a/ This drainage area includes the "Triple Cities" area and was obtained by subtracting from the drainage area for the Vestal station the sum of the areas for the Conklin and Chenango Forks stations.

b/ Actual runoff for the southwestern part of Broome County obtained by subtracting from the runoff at Vestal the sum of the runoff at the Conklin and Chenango Forks stations.

c/ Theoretical runoff computed from annual precipitation only, assuming that records at Binghamton are applicable to all of southwestern Broome County.

d/ Obtained by subtracting actual runoff from theoretical runoff and converting into millions of gallons. This represents the maximum possible contribution to ground water storage ignoring losses due to evaporation and transpiration.

e/ Values for annual evaporation equal the summation of monthly evaporation obtained by utilizing monthly precipitation and mean temperature at Binghamton and Meyer's 17/ evaporation curve for land areas. Results were multiplied by an estimated coefficient of 0.95 to give some weight to watershed and soil characteristics 18/

f/ Computed by reducing the theoretical mean daily ground-water storage for loss due to evaporation from the ground.

g/ Computed from annual pumpage totals given in Table 1. Figures cover an estimated 85% of the total ground-water withdrawal in the area.

h/ All figures for this year are for the period March 3rd to December 31st inclusive (304 days), since records at Vestal station began on March 3rd.

k/ All figures for this year are for the period January 1st to September 30th inclusive (274 days). Records are not available at this writing for the months of October, November and December.

17/ Meyer, Adolph F., Elements of Hydrology, John Wiley and Sons, pp. 455-458, 1944.

18/ Lounsbury, C. and Hasty, A. H., Soil Survey of Broome County, N. Y., U. S. Dept. of Agri., Series 1932, No. 11.

As no local evaporation records are available an attempt was made, through use of Meyer's[16] evaporation curve, to estimate the general magnitude of evaporation from the land areas in the southwestern part of Broome County. With values for annual evaporation tentatively determined the theoretical mean daily contributions to ground-water storage were reduced accordingly to give better estimates of the amounts of water actually available for storage. If an annual transpiration loss of 6 inches of water is assumed (a conservative figure), based again on Meyer's[18] hydrologic investigations, the values given for "adjusted mean daily ground-water storage" should be further reduced an average of 18 percent. These final figures, when compared with values for mean daily ground-water withdrawal, suggest that the present development of ground water in the area at critical times approaches 40 percent of the total available supply, while on the average it approaches from 20 to 25 percent.

All the foregoing discussion and development of table 3 centers around an attempt to fill in as much of the hydrologic cycle as possible, based both on data for the area under study and on carefully-drawn supporting estimates. The basic relation upon which the table is developed might be conveniently stated as follows:

(Precipitation) = (Runoff) + (Evaporation) + (Transpiration) + (Change in GW Storage)

"Change in GW Storage" might be further resolved into:

(Surface Contributions) - (Pumpage) + (Change in GW Flow)

16/ Meyer, Adolf F., Elements of hydrology, John Wiley and Sons, pp. 455-458, 1944.

18/ Op. cit. p. 281 (see footnote 16).

For the period covered by table 3 computations of annual runoff and change in ground-water storage have given positive results. That is, there has been an annual excess of surface water leaving the area over the amount of surface water entering the area; and annual precipitation has always exceeded combined runoff, evaporation, and transpiration, thereby providing for increases in ground-water storage. It should be pointed out, however, that all of this storage is not in the so-called Triple Cities area where the principal ground-water withdrawal occurs. Some of the storage is in areas where no amount of increased pumpage from present well fields will ever draw upon it. Thus, under the present localization of ground-water development in the southwestern part of Broome County, it is possible that appreciably more than 50 percent of the total available supply is being utilized.

If in table 3, periods shorter than a year had been used the balance of the hydrologic equation would have appeared quite different. In a short period taken to include the middle or latter part of the summer, for example, negative changes in ground-water storage would be evident as pumpage exceeded contributions from the surface and as the water levels declined toward the annual lows. Runoff would be low in contrast to high evaporation and transpiration losses. Conversely, in a short period including the early spring, runoff would be high, combined evaporation and transpiration losses exceedingly low, and large positive changes in ground-water storage would be evident as water levels rose to annual highs. Pumpage would then be considerably less than the contributions to ground water from the surface.

Discussion of the relations between ground water and surface water would not be complete without pointing out that at present an overall quantitative analysis is virtually impossible. Among the factors contributing to to this are the fact that sizable quantities of water are returned to ground-water and surface-water storage after use; the lack of local records on evaporation and transpiration; inadequate precipitation data for the entire watershed area; and the incompleteness of the inventory of the users of ground water in the area. Despite these factors, however, the data presented in table 3 suggest the ultimate stage beyond which ground-water development cannot go.

QUALITY OF WATER

Surface water

The range in the quality of natural waters found in the southwestern part of Broome County is illustrated by the 33 analyses given in table 4. These analyses have been arranged in three groups to permit ready comparison of water samples collected from surface sources, from underground supplies in unconsolidated deposits, and from smaller underground supplies in rock.

Analyses of samples collected from surface sources are shown as numbers 1 through 5 in table 4. Although chlorides are very low they still exceed the normal of 0.4 part per million for natural waters in this area, as determined by Jackson[19] some years ago. The difference can be readily accounted for by the industrial wastes and sewage that are discharged into the streams. Sample 4, in particular, was collected near the north bank of the Susquehanna River where the river currents form a large eddy that tends to circulate waste material in the same local area for extended intervals of time. Thus the chloride concentration for this sample is more than double the value for three of the four remaining samples, indicating a higher degree of pollution. The pH determinations indicate slightly alkaline waters with values a little above the neutral value of 7.0. Hardness and alkalinity are low, in marked contrast to ground-water samples.

Ground water from unconsolidated deposits

Analyses 6 through 25 in table 4 cover water samples collected from the sands and gravels in which the principal potable ground-water supplies

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19/ Jackson, Daniel D., The normal distribution of chlorine in the natural waters of New York and New England: U. S. Geol. Survey Water-Supply Paper 144, pp. 28-31, 1905.

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Table 4. Analyses of Natural Waters of Southwestern Broome County

(Parts per Million)

Item No.	SOURCE	Total Solids	Iron (Fe)	Manganese (Mn)	Sulfate (SO_4)	Chloride (Cl)	Soap Hardness as ($CaCO_3$)	Alkalinity	Color	Turbidity	pH
	Surface Waters										
1	Chenango River at DeForest Street bridge, Binghamton, Dec. 20, 1945	110	0.5	0.015	13.6	2.0	80	78	0	T	7.5
2	Susquehanna River at Binghamton Water Plant, Nov. 1942 a/	75				3.6	65	50			
3	Susquehanna River at Binghamton Water Plant, Dec. 20, 1945	80	0.2	0.015	14.2	1.8	68	55	0	T	7.4
4	Susquehanna River at Camden Street, Johnson City, Dec. 20, 1945					6.0	84	80			
5	Susquehanna River at Hwy.#26 bridge, Endicott, Dec. 20, 1945	120	0.1	<0.010	12.9	2.6	72	65	0	T	7.5
	Ground Waters-----from unconsolidated deposits										
6	Bm 14, Town of Fenton, July 10, 1945	227	0.16	0.075	13.7	4.4	140	128	0	T	7.5
7	Bm 24, Rogers School, Conklin, July 11, 1945	338	1.3	0.06	46.1	43.0	156	58	0	10	7.1
8	Bm 25, Binghamton Water Plant, Nov. 1942 a/	360				14.2	285	230			
9	Bm 26, Binghamton, March 7, 1940 a/	270	0.01	T		12.6	240	178	0	0	7.5
10	Bm 26, Binghamton, March 21, 1940 a/	242	0.01	T		10.6	220	150	0	0	7.5
11	Bm 26, Binghamton, Nov. 1942 a/	330				12.4	230	160			
12	Bm 26, Binghamton, Dec. 20, 1945	234	0.1	<0.010	29.1	17.0	164	155	0	T	7.5
13	Bm 27, A and B, Cloverdale Farms Co., Binghamton, July 13, 1945	582	0.15	0.5	81.5	15.6	268	164	0	T	7.1
14	Bm 27, A and B, Cloverdale FarmsCo., Binghamton, Dec. 20, 1945	506	< 0.03	1.25	170.4	25.0	150	161	0	T	6.8
15	Bm 38, Ansco Corp., Binghamton, Dec. 20, 1945					12.0	270	192			
16	Bm 42, Ansco Corp., Binghamton, July 10, 1945	597	0.5	0.01	60.0	16.4	340	278	0	T	7.3
17	Bm 42, Ansco Corp., Binghamton, Dec. 20, 1945					27.0	380	292			
18	Bm 50, Johnson City Water Plant, July 11, 1945	342	0.06	0.015	24.9	9.0	192	175	0	T	7.3
19	Bm 51, Johnson City Water Plant, Dec. 20, 1945						148	130			
20	Bm 58, Endicott, Aug. 26, 1942 a/	204	0.04			7.1	198	155	0	0	

Table 4.——Continued.

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Item No.	SOURCE	Total Solids	Iron (Fe)	Manganese (Mn)	Sulfate (SO_4)	Chloride (Cl)	Soap Hardness as ($CaCO_3$)	Alkalinity	Color	Turbidity	pH
21	Bm 58, Endicott, Dec. 20, 1945						144	140			
22	Bm 61, International Business Machines, Endicott, July 13, 1945	421	0.15	0.05	15.5	59.0	212	170	0	T	7.3
23	Bm 69, Endicott Water Plant, Dec. 20, 1945	199	<0.03	0.30	49.9	8.4	148	129	0	T	7.6
24	Bm 78, Endicott, Dec. 20, 1945					12.0	230	192			
25	Bm 83, Tri-Cities Airport, Union, July 12, 1945	179	0.06	0.01	12.1	5.4	108	102	0	T	7.5
	Ground Waters——from rock										
26	Bm 6, C. C. Rider, Chenango Forks, July 25, 1945	241	0.10	0.05	9.2	9.0	136	131	0	T	7.5
27	Bm 12, Chenango Bridge, July 25, 1945	302	0.25	< 0.01	< 1.0	72.0	32	118	0	T	8.0
28	Bm 21, Binghamton State Hospital, July 25, 1945	7535	9.0	0.15	< 1.0	4150	800	144	0	120	8.3
29	Bm 28, Crowley Milk Co., Binghamton, July 24, 1945	1292	0.25	0.03	< 1.0	670	90	239	0	5	8.5
30	Bm 33, Fowler Dick Walker Dep't Store, Binghamton, July 24, 1945	2672	0.20	0.03	< 1.0	1475	176	183	0	5	7.9
31	Bm 53, Hazard-Lewis Farms, Vestal, March, 1945 a/		0.02				160	137			7.2
32	Bm 53, Hazard-Lewis Farms, Vestal, Dec. 20, 1945					800	380	145			
33	Bm 54, Hazard-Lewis Farms, Vestal, July 24, 1945	721	0.15	0.05	10.8	310	100	191	0	5	7.4

a/ Analyzed by Nelson and Lauder, Chemists, Binghamton, N. Y.

Notes:

Unless otherwise indicated all analyses were made by the N. Y. State Department of Health laboratory in Albany.

Locations and descriptions for the wells from which ground-water samples were taken may be found in the "Record of Wells" section of this report.

Item No. 9 was collected at the start of a continuous pumping period and Item No. 10 at the end of the period.

"T" indicates TRACE.

"Total Solids" is the sum of the Fixed Solids and the Volatile Solids.

Alkalinity determined by using methyl orange.

in this area are developed. The chloride, hardness, and alkalinity for these samples are decidedly greater than for the surface-water samples. The hardness averages more than 200 parts per million. This requires, for municipal supplies, either a softening process at the water plant or the use of special soaps by the customers. Apparently, however, the several industries in the area currently using ground-water supplies can operate satisfactorily with little or no water treatment. The water is still relatively low in chloride and iron content when compared with ground waters from many other parts of the country.

Samples 9 and 10 in table 4 were collected at the start and finish of a 14-day continuous pumping test on supply well Bm 26 of the city of Binghamton. During this period the well was pumped at an average rate in excess of 800 gallons per minute and, as indicated by the analyses, there was a slight change in the quality of the water. Values for chloride, soap hardness, alkalinity, and total solids show an average decrease of about 13 percent during the test.

A comparison of analyses 4 and 19 reveals the extent of the separation between the ground and surface waters in a given area. The Johnson City Water Plant wells are located within 200 feet of the Susquehanna River and are pumping an average of more than 5 million gallons a day, yet values for hardness and alkalinity remain typical of ground water and show no marked dilution by surface water. Similar comparisons may be made between analyses 1 and 12 and analyses 5 and 23. Analyses 6, 20, 21, 22, and 25 in table 4 also represent water samples collected from wells located within several hundred feet of either the Chenango or the Susquehanna River, yet the analyses are still typical of ground water rather than surface water.

Despite the foregoing discussion, however, it is significant to point out that apparently values for chloride, hardness, and alkalinity of ground-water samples collected from wells located near major surface streams are slightly lower than similar values for samples taken from wells more remote from any surface stream. A comparison of analyses 15, 16, and 17 with analyses 6, 20, 21, 22, and 25 illustrates this point. This implies that, although ground-water supplies are not immediately affected by or directly connected to surface-water sources, there is a slow, persistent downward percolation of water from these surface sources through and around the relatively impermeable clays and silts into the productive sands and gravels that constitute the principal ground-water reservoirs.

Ground water from rock

Analyses 26 through 33 in table 4 are for water samples collected from wells finished at various depths in the bedrock underlying the unconsolidated glacial and river deposits. The analyses for this group of samples are distinctive from those for each of the two preceding groups. Perhaps the most distinctive features are the high values for chloride and total solids and the low values for sulfate. The pH values indicate a higher degree of alkalinity than for either of the other two groups of samples collected. In general, the quality of ground water tapped by wells that are finished in rock is poor; the water in most places is not potable and has only a few limited industrial uses, as in air conditioning for buildings and or washing operations in bottling plants.

Although some wells have been sampled on more than one occasion the coverage has not been complete enough to indicate seasonal variations in the quality of water or any steady decline or improvement in the quality due to protracted pumpage. These are phases of the investigation requiring further work in the future to give additional information on the sources and movement of ground water.

SUMMARY

This report presents the basic information gathered to date for the southwestern part of Broome County where, if present trends are continued, localized overdevelopment of the ground-water resources may eventually occur.

The principal aquifers are the sand and gravel beds scattered through the unconsolidated glacial deposits in the valleys of the Chenango and Susquehanna Rivers. The total average daily pumpage in the area investigated increased from about 14.7 million gallons in 1937 to about 20.9 million gallons in 1944, or more than 40 percent in 8 years. Accompanying this increase in pumpage has been a net average decline in ground-water levels, in the areas of withdrawal, of about 15 feet. At critical times ground-water withdrawal has approached 40 percent of the estimated total available supply, but it has been concentrated in only a part of the total area in which wells could be successfully developed. This suggests that further development is possible but that it should be made in thos sections of the area that are currently underdeveloped, as far away as possible from present well fields.

The hardness of ground water in this area averages more than 200 parts per million; the chloride and iron content are relatively low, averaging approximately 15 and 0.1 parts per million, respectively; and the alkalinity averages approximately 175 parts per million. The water from wells drilled into rock generally is of inferior quality and generally is not potable, owing to high concentrations of chlorides and total solids.

The logs of wells and borings indicate more or less indefinitely some of the areas where potable ground-water supplies may be satisfactorily obtained. Considerable additional drilling and subsurface exploration is needed, however, to define in more detail the location and extent of the water-bearing sands and gravels and the old preglacial valleys. Similar needed extensions of nearly all the other types of data included in this report are indicated. Water-level observations should be made periodically on an area-wide basis to show the source, movement, and seasonal variation in levels of ground water, and the extent to which the various cones of depression created by present well fields interrupt and influence normal ground-water flow. Controlled pumping tests should be made to obtain values for the transmissibility and storage capacity of some of the typical sand and gravel aquifers in the area. Such tests would provide data for determining the ideal spacing of wells to give the highest overall efficiency for any proposed well field. Periodic collection of water samples and determinations of ground-water temperatures are desirable to indicate any seasonal variations or any tendency for induced infiltration from surface sources into ground-water reservoirs where existing well fields have created deep cones of depression. Additional inventory of wells and pumpage is necessary to permit further refinements of computations that may indicate approach of the future ground-water development toward the ultimate safe yield of all the aquifers.

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RECORDS OF WELLS

The following compilation of well records covers all wells used in preparing this report. It does not, therefore, represent a complete compilation of all wells in the southwestern part of Broome County. Records of 58 wells are presented and their locations are shown in figure 2.

The well-numbering system is the same as has been used by the New York State Water Power and Control Commission and the U. S. Geological Survey in other areas. The letters "Bm" prefixed to each well number signify the county name. Wells are numbered primarily in the order in which they are found, although for this report it was possible to introduce a general geographical sequence to the numbering, proceeding from northeast to southwest.

All the wells reported herein are either currently in use or, if abandoned, are still intact and available for either observation or pumping-test purposes.

An asterisk following a well number indicates that a water sample was collected and the analysis may be found in the quality of water section of this report.

Bm. 6* C. C. Rider, Chenango Forks. Drilled by E. Fitser in May 1945. Altitude 905 feet above mean seal level. Driller's log.

	Thickness (feet)	Depth (feet)
Gravel	15	15
Rock	65	80

Casing:	5-inch.
Depth:	80 feet.
Static water level:	11 feet.
Drawdown:	4 to 5 feet.
Yield:	10 gallons a minute.
Aquifer:	Blue stone.

Bm. 12* Chenango Bridge Water District No. 1, Chenango Bridge. About 75 feet north of Clark Avenue and about 250 feet east of Kattellville Rd. Drilled by Cline and Maker in 1928. Altitude 890 feet above mean sea level. Driller's log.

Depth to shale rock about 25 feet

Casing:	8-inch.
Depth:	225 feet.
Static water level:	100 to 150 feet.
Yield:	20 gallons a minute.

Bm. 14* Hillcrest Water District No. 1, Town of Fenton. About 650 feet north of Ronan St. and about 700 feet west of Chenango St. Drilled by Artesian Well and Equipment Co. in 1929. Altitude 865 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Very fine sand and clay....................	169	169
Sand and gravel............................	50	219
Rock at....................................		219

Casing:	16-inch.
Depth:	219 feet.
Static water level:	22 feet.
Yield:	200 gallons a minute.
Aquifer:	Sand and gravel from 169 to 219 feet.

(Note: For additional data see the quantitative section of this report.)

Bm. 15. Hillcrest Water District No. 1, Town of Fenton. About 70 feet north of well Bm. 14. Drilled by Artesian Well and Equipment Co. in 1929. Altitude 865 feet above mean sea level.

Casing:	16-inch.
Depth:	219 feet.
Static water level:	22 feet.
Yield:	200 gallons a minute.
Aquifer:	Sand and gravel from 169 to 219 feet.

Bm. 16. Hillcrest Water District No. 1, Town of Fenton. About 49 feet northwest of well Bm. 14. Drilled by Artesian Well and Equipment Co. in 1929. Altitude 860 feet above mean sea level.

Casing:	6-inch.
Depth:	215 feet.
Static water level:	16 feet.

(Note: For additional data see the quantitative section of this report.)

Bm. 17. Girl Scout Camp, Johnson City. About 400 feet west of Reynolds Rd. and 600 feet north of Overbrook Rd. Drilled by Kopyar in the summer of 1944. Altitude 1,000 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Hardpan	90	90
Shale	8	98
(very little water from 96 to 97 feet)		
Blue stone (limestone)	42	140

Casing:	6-inch.
Depth:	140 feet.
Static water level:	70 feet.
Yield:	25 gallons a minute.

Bm. 21.* Binghamton State Hospital. About 75 feet northeast of Erie R. R. and 1.4 miles southeast of eastern City line. Drilled around 1925. Altitude 860 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Hardpan (no water)	100	100
No record	15	115
Rock, hard	10	125
Shale rock	25	150

(Continued on next page)

Bm. 21* (Cont'd.)

Casing:	8-inch.
Depth:	182 feet.
Static water level:	35 feet.
Yield:	Bailed 70 gallons a minute with no drawdown.
Installed pump capacity:	54 gallons a minute.

Bm. 22. Binghamton State Hospital. About 75 feet north of the Susquehanna River and 1,500 feet south of well Bm. 21. Drilled by R. Shere in 1919. Altitude 850 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Boulders	20	20
Hardpan, blue (no water down to 100 feet)	99	119
Shale rock	20	139
Bed rock at		139

Casing:	6-inch.
Depth:	182 feet.
Static water level:	40 to 50 feet.

Bm. 24.* Rogers School, near (east of) Binghamton. About 500 feet south of the Susquehanna River opposite the mouth of Acre Creek. Drilled by Borden Construction Co. in 1928.

Altitude 850 feet above mean sea level

Casing:	8-inch.
Depth:	180 feet.
Yield:	800 gallons a day.

Bm. 25.* City of Binghamton. Near eastern point of triangle formed by Court St., Brandywine Ave. and Erie R. R. Dug and driven in 1940 as a Ranney type collector. Altitude 837 feet above mean sea level. Driller's log (see Boring No. 20 in Record of Borings section).

Casing:	170-inch.
Depth:	23 feet.
Screen:	7 lateral collectors.
Drawdown:	6.3 feet.
Yield:	1,405 gallons a minute.

Bm. 26.* City of Binghamton. East bank of Chenango River about 600 feet south of DeForest St. bridge. Drilled by Layne-New York Co. in 1940. Altitude 838 feet above mean sea level. Driller's log (see Boring No. 12 in Record of Borings section).

Casing:	16-inch.
Depth:	90 feet.
Screen:	20 feet by 16-inch seated at 90 feet.
Drawdown:	12 feet.
Yield:	877 gallons a minute.
Installed pump capacity:	800 (plus) gallons a minute.
Aquifer:	Sand, coarse, blue, and gravel from 72 to 87 feet.

(Note: For additional data see table 1.)

Bm. 27 A & B.* Cloverdale Farms Co., Binghamton. Northeast corner of Jackson and Moore Sts. Drilled by Cline and Son in 1924 and 1930. Altitude 840 feet above mean sea level. Data for these two wells, 50 feet apart and hooked to a single pump, are identical.

Casing:	8-inch.
Depth:	45 feet.
Static water level:	20 feet.
Yield:	12 gallons a minute.
Aquifer:	Fine sand.

Bm. 28.* Crowley Milk Co., Inc., Binghamton. Northwest corner of Rockbottom St. and Conklin Ave. Drilled by Cline and Son in 1935. Altitude 855 feet above mean sea level. Driller's log.

Depth to rock 18 feet

Casing:	8-inch.
Depth:	425 feet.
Static water level:	208 feet.
Drawdown:	188 feet.
Yield:	65 gallons a minute.
Installed pump capacity:	100 gallons a minute.

Bm. 31. Security Mutual Bldg., Binghamton. Southeast corner of Exchange and Court Sts. Drilled by H. Cornell. Altitude 860 feet above mean sea level. Driller's log.

Depth to rock 60 feet

Casing:	5-inch.
Depth:	305 feet.

Bm. 33.* Fowler, Dick and Walker Dept. Store, Binghamton. Southwest corner of Dwight and Water Sts. Drilled by G. Thomas in the summer of 1941. Altitude 850 feet above mean sea level. Driller's log.

Depth to rock 40 feet

Casing:	12-inch and 8-inch.
Depth:	725 feet.
Static water level:	20 feet.
Yield:	200 gallons a minute.
Installed pump capacity:	300 gallons a minute.

(Note: Well will go dry if pumped at capacity rate for 6 to 9 hours. Refills casing by next day.)

Bm. 37. Ritz Theatre, Binghamton. North side of Clinton St. near (west of) Murray St. Drilled by H. H. Cranston and Son in June 1938. Altitude 850 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Gravel, coarse, & sand, some clay, yellow	7	7
Sand, gravel & clay, yellow	35	42
Sand, coarse with some gravel (small vol. of water)	5	47
Sand & gravel, some clay, thin layer of gravel with water	13	60
Sand, gravel & clay, some cobbles, thin layers of gravel with water	20	80
Sand, very fine, dirty	2	82
Sand, fine, some gravel	5	87
Sand, hard packed, some gravel	6	93
Gravel & fine sand, some water	4	97
Sand, fine	3	100
Sand & gravel	2	102
Sand & gravel, some clay	3	105
Sand & gravel, fine	3.5	108.5
Clay, light bluish gray, blue pebbles	2.5	111
Residual shale gravel	2	113
Shale	97	210

Casing:	8-inch.
Depth:	135 feet.
Screen:	10 feet by 5-inch Johnson No. 80 slot set at 105.8 feet.
Static water level:	24.5 feet.
Drawdown:	15.5 feet.
Yield:	50 gallons a minute.
Installed pump capacity:	50 gallons a minute.
Aquifer:	Sand and gravel from 96 to 106 feet.

Bm. 38.* Ansco Corp., Binghamton. Northwest corner of Spruce and Elm Streets. Drilled in 1942. Altitude 838 feet above mean sea level. Driller's log.

(Continued on next page)

Bm. 38.* (Cont'd.)

	Thickness (feet)	Depth (feet)
Ashes and clay	9	9
No record	3	12
Silt, sand very fine with clay	53	65
No record	5	70
Gravel, coarse and medium, large stones	40	110
Sand, fine	5	115
Silt and sand, fine	5	120
Sand, coarse, and gravel, fine	5	125
No record	3	128
Rock, blue shale	7	135

Casing:	24-inch.
Depth:	100 feet.
Screen:	35 feet by 24 inch.
Static water level:	30 feet.
Yield:	1,100 gallons a minute.
Installed pump capacity:	1,200 gallons a minute.

(Note: For additional data see table 1.)

Bm. 39. Ansco Corp., Binghamton. About 180 feet north of Elm St. and about 160 feet east of West St. extended. Drilled in 1941. Altitude 843.9 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Sand, fine, gravel, medium, and some clay	116	116
Rock at		116

Quicksand layers at 40, 50, 75 and 80 feet.
Medium gravel layers at 90, 95, 105 and 114 feet.
Clay layers at 100 and 110 feet.

Casing:	6-inch.
Depth:	116 feet.
Static water level:	43 feet.

Well is not in use and is available for observation purposes.

Bm. 40. Ansco Corp., Binghamton. East side of Charles St. about 360 feet north of Grace St. Drilled in 1935. Altitude 848.5 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
No record	25.5	25.5
Gravel, medium	15	40.5
Gravel, medium and sand, fine	40	80.5
Gravel, medium and hardpan	5	85.5
Gravel, coarse	15	100.5
Gravel, medium and sand	12	112.5
Rock at		112.5

Casing:	12-inch.
Depth:	100 feet.
Screen:	Cook, 15 feet by 12-inch by 3/32-inch slots from 63.5 to 78.5 feet.
Drawdown:	10 feet.
Yield:	250 gallons a minute.
Installed pump capacity:	800 gallons a minute.
Aquifer:	Medium gravel and fine sand.

(Note: For additional data see table 1.)

Bm. 41. Ansco Corp., Binghamton. About 380 feet east of Charles St. and about 120 feet north of Field St. extended. Drilled in 1935. Altitude 848.5 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
No record	34	34
Sand, fine	25	59
Sand and silt	5	64
Gravel, medium and sand	5	69
Gravel, coarse	5	74
Gravel, medium	5	79
Gravel, coarse	5.5	84.5
Sand and clay, at		84.5

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Bm. 41. (Cont'd.)

Casing:	12-inch.
Depth:	100 feet.
Screen:	Cook, 10 feet by 12-inch by 3/32-inch slots from 74.5 to 84.5 feet.
Drawdown:	15 feet.
Yield:	200 gallons a minute.
Installed pump capacity:	500 gallons a minute.
Aquifer:	Gravel, coarse and medium.

(Note: For additional data see table 1.)

Bm. 42.* Ansco Corp., Binghamton. East side of Charles St. at Field St. Drilled in 1935. Altitude 848.5 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
No record	20.5	20.5
Gravel, medium, and sand	15	35.5
Gravel, medium, and stones	15	50.5
Gravel, medium	10	60.5
Gravel, coarse	15	75.5
Gravel, medium and fine	15	90.5
Gravel, fine	5	95.5
Gravel, medium, and clay	10	105.5
Gravel, fine, and clay	5	110.5
Sand and clay	10	120.5
Gravel, fine, and sand	5	125.5
Gravel, fine, and clay	7	132.5

Casing:	16-inch.
Depth:	100 feet.
Screen:	Cook, 28 feet by 16-inch by 3/32-inch slots from 64.5 to 92.5 feet.
Drawdown:	4 feet.
Yield:	1,200 gallons a minute.
Installed pump capacity:	2,000 gallons a minute.
Aquifer:	Gravel, coarse, medium, and fine.

(Note: For additional data see table 1.)

Bm. 43. Ansco Corp., Binghamton. About 185 feet north of well Bm. 41. Drilled in 1935. Altitude 848.5 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
No record	79	79
Gravel, coarse	15	94
Gravel, medium, and clay	5	99

Casing:	12-inch.
Depth:	100 feet.
Screen:	Cook, 10 feet by 12-inch by 3/32-inch slots from 79.5 to 89.5 feet.
Drawdown:	12 feet.
Yield:	150 gallons a minute.
Installed pump capacity:	300 gallons a minute.
Aquifer:	Gravel, coarse.

(Note: For additional data see table 1.)

Bm. 44. Ansco Corp., Binghamton. About 260 feet north of Field St. and about 140 feet west of Charles St. extended. Drilled in 1937. Altitude 848.5 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
No record	18.5	18.5
Gravel, medium	10	28.5
Gravel, medium, and sand	5	33.5
Gravel, medium	5	38.5
Gravel, coarse	9	47.5
Stones, coarse	3	50.5
Sand, fine	25	75.5
Gravel, medium, and sand	5	80.5
Gravel, medium, and rock	5	85.5
Sand, fine	5	90.5
Gravel, coarse, and sand	5	95.5
Gravel, medium, and sand	9	104.5
Gravel, fine, and sand	17	121.5
Rock at		121.5

(Continued on next page)

Bm. 44. (Cont'd.)

Casing:	18-inch.
Depth:	100 feet.
Screen:	Cook, 25 feet by 18-inch by 3/32-inch slots from 92.6 to 117.6 feet.
Drawdown:	7 feet.
Yield:	1,800 gallons a minute.
Installed pump capacity:	2,000 gallons a minute.
Aquifer:	Gravel, coarse, medium and fine, and sand.

(Note: For additional data see table 1.)

Bm. 45. Ansco Corp., Binghamton. Western side of Colfax Ave. at May St. Drilled in 1941. Altitude 840 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Clay, gravel, medium and coarse, and sand.......	65	65
No record..	5	70
Sand, very fine, and clay........................	18	88
No record..	2	90
Rock, blue shale, at.............................		90

Casing:	8-inch.
Depth:	90 feet.

Well is not in use and is available for observation purposes.

Bm. 46. Ansco Corp., Binghamton. Southeast corner of intersection of Emma St. and DL & W R. R. Drilled in 1941. Altitude 856.2 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Sand, fine, and gravel, medium...................	45	45
Sand, fine, gravel, and some clay................	15	60
No record..	5	65
Gravel, coarse ($\frac{1}{2}$-inch), and sand, fine.........	10	75
No record..	5	80
Clay and sand, fine..............................	10	90
No record..	2	92
Rock, blue shale, at.............................		92

(Continued on next page)

Bm. 46. (Cont'd.)

Casing:	6-inch.
Depth:	92 feet.
Static water level:	40 feet.

Well is not in use and is available for observation purposes.

Bm. 47. Water Dep't., Village of Johnson City. Near southwest corner of pool in C. F. Johnson Park. Drilled by Kelly Well Drilling Co. in 1928. Altitude 850 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Clay and stones	12	12
Clay and sand	8	20
Clay and sandy	8	28
Sand and clay	7	35
Sand, hard, and gravel	10	45
Sand, fine	13	58
Clay	2.7	60.7
Boulders at		60.7

Casing:	25-inch.
Depth:	61 feet.
Screen:	26 feet set from 35 to 61 feet.
Static water level:	18 feet.
Drawdown:	4 feet.
Yield:	500 gallons a minute.
Installed pump capacity:	1,000 gallons a minute.

Well is for emergency and pool filling use only.

Bm. 48. Water Dep't., Village of Johnson City. Northwest corner of Ball Park at North and North Broad Sts. Drilled by Kelly Well Drilling Co. in 1928. Altitude 840 feet above mean sea level. Driller's log.

(Continued on next page)

Bm. 48. (Cont'd.)

	Thickness (feet)	Depth (feet)
Clay, gravel	11	11
Gravel	3	14
Clay	2	16
Sand, gravel	14	30
Clay, sandy, blue, and stones	17	47
Hardpan	1	48
Gravel, hard, and stones	8	56
Sand, gravel, stones and boulders	19	75
Gravel, hard, clay and boulders	7	82

Casing:	25-inch.
Depth:	80 feet.
Screen:	26 feet set from 54 to 80 feet.
Static water level:	18 feet.
Drawdown:	7.5 feet.
Yield:	615 gallons a minute.
Installed pump capacity:	2,100 gallons a minute.

Well is for emergency use only.

Bm. 49. Water Dep't., Village of Johnson City. Northwest corner of Ball Park at North and North Broad Sts. Drilled by Kelly Well Drilling Co. in 1928. Altitude 840 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Fill	3	3
Clay and stones	7	10
Gravel, sand and stones	13	23
Clay, sandy, blue	9	32
Clay, blue, and stones	11	43
Clay, hard	4	47
Stones	4	51
Sand, gravel and stones	11	62
Sand and gravel	3	65

Casing:	18-inch.
Depth:	65 feet.
Static water level:	18 feet.
Drawdown:	6 feet.
Yield:	500 gallons a minute.
Installed pump capacity:	2,100 gallons a minute.

Well is for emergency use only.

Bm. 50.* Water Dep't., Village of Johnson City. About 100 feet south of Elbon St. and 100 feet east of Camden St. Drilled by Kelly Well Drilling Co. in 1930-31. Altitude 830 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Sand, gravel and stones	9	9
Sand, gravel and clay	13	22
Stones, large and small	16	38
Hardpan, gravel, stones	17	55
Sand and gravel, fine to coarse	34	89
Sand, fine	13	102
Clay, blue and stones, at		102

Casing:	25-inch.
Depth:	100 feet.
Screen:	43 feet, gravel walled to 38-inch effective diameter, set from 57 to 100 feet.
Static water level:	35 feet. (See also Fig. 6)
Yield:	2,100 gallons a minute.
Installed pump capacity:	2,100 gallons a minute.

(Note: For additional data see table 1.)

Bm. 51.* Water Dep't., Village of Johnson City. West side of Camden St. about 160 feet south of Elbon St. Drilled by Kelly Well Drilling Co. in 1930-31. Altitude 830 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Clay, sand, gravel and small stones	20	20
Gravel and stones, fine and coarse	10	30
Sandstones, dirty	4	34
Gravel and stones	18	52
Stones, large and small	14	66
Hardpan and clay	5	71
Sand, fine, clay and stones	6	77
Sand, gravel and stones	9	66
Sand, fine to clay, blue	14	100

(Continued on next page)

Bm. 51.* (Cont'd.)

Casing:	25-inch.
Depth:	101 feet.
Screen:	35 feet set from 66 to 101 feet.
Static water level:	35 feet. (See also fig. 6)
Drawdown:	2 feet.
Yield:	2,180 gallons a minute.
Installed pump capacity:	2,100 gallons a minute.

(Note: For additional data see table 1.)

Bm. 52. Water Dep't., Village of Johnson City. West side of Camden St. about 40 feet south of Elbon St. Drilled by Kelly Well Drilling Co., in 1930-31. Altitude 830 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Clay, sandy and stones	14	14
Sand, gravel and stones	50	64
Gravel and stones, large	21	85
Stones and clay	3	88
Hardpan and stones, at		88

Casing:	25-inch.
Depth:	89 feet.
Screen:	42 feet set from 47 to 89 feet.
Static water level:	35 feet.
Drawdown:	8 feet.
Yield:	2,200 gallons a minute.
Installed pump capacity:	2,100 gallons a minute.

(Note: For additional data see table 1.)

Bm. 53.* Hazard-Lewis Farms Inc. About 225 feet south of the Susquehanna River and about 600 feet north of the old Vestal Road one mile west of the western city line of Binghamton. Drilled by Hall and Co. in March 1945. Altitude 835 feet above mean sea level. Driller's log.

(Continued on next page)

Bm. 53.* (Cont'd.)

	Thickness (feet)	Depth (feet)
Top soil and hardpan................................	15	15
Limestone, medium hard..............................	30	45
Limestone, soft.....................................	45	90
No record...	15	105
First yield zone at.................................		105
No record...	9	114

Casing:	8-inch.
Depth:	114 feet.
Static water level:	15 feet.
Drawdown:	78 feet.
Yield:	90 gallons a minute.

Bm. 54.* Hazard-Lewis Farms, Inc. About 860 feet south of the Susquehanna River and about 40 feet south of the old Vestal Road one mile west of the western city line of Binghamton. Drilled by Lee and Thomas in 1940. Altitude 842 feet above mean sea level.

Casing:	8-inch.
Depth:	154 feet.
Static water level:	25 feet.
Yield:	20 gallons a minute.
Installed pump capacity:	50 gallons a minute.

Well will pump dry after 5 to 6 hours steady pumping.

Bm. 56. International Business Machines Corp. Country Club. Southeast corner of Country Club grounds. Drilled by Rinbrand Well Drilling Co. in January 1937. Altitude 830 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Boulders and clay...................................	19	19
Shale shell...	4	23
Clay, yellow, streaks of sand and gravel.......	48	71
Gravel, fine and sand..............................	4	75
Rock, shale, seams filled with clay and sand at....................................		75

(Continued on next page)

Bm. 56. (Cont'd.)

Casing:	12-inch.
Depth:	75 feet.
Screen:	20 feet with 1/16-inch slots.
Yield:	600 gallons a minute.
Installed pump capacity:	600 gallons a minute.

Bm. 58.* Endicott Water Works Co., Endicott. North bank of the Susquehanna River at Davis St. extended and below (southwest of) the mouth of Hooper Co. Drilled by Kelly Well Drilling Co. in 1941. Altitude 820 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Mud	10	10
Sand and gravel	10	20
Clay and gravel	10	30
Sand and gravel	10	40
Gravel, fine, sandstone	10	50
Sand and gravel	46	96
Clay	9	105

(Note: See also log for Boring 97.)

Casing:	25-inch.
Depth:	96 feet.
Screen:	50 feet by 25-inch set from 46 to 96 feet.
Drawdown:	11 feet.
Yield:	1,500 gallons a minute.
Installed pump capacity:	1,500 gallons a minute.

(Note: For additional data see table 1.)

Bm. 59. International Business Machines Corp., Endicott. About 520 feet east of Massachusetts Ave. and 130 feet south of River View Dr. Drilled by Rinbrand Well Drilling Co. in September 1940. Altitude 830 feet above mean sea level. Driller's log.

(Continued on next page)

Bm. 59. (Cont'd.)

	Thickness (feet)	Depth (feet)
Gravel	32	32
Clay	14	46
Sand	10	56
Clay and gravel	4	60
Hard sand	7	67
Gravel and sand	8	75
Hard sand	19	94
Clay	4	98
Clay and sand	17	115
Sand and gravel	12	127
Gravel and sand	14	141
Gravel, little clay	7	148
Course gravel and water	5	153
Clay	2	155
Broken rock	2	157

Casing:	10-inch.
Depth:	163 feet.
Screen:	22 feet set from 141 to 163 feet.
Installed pump capacity:	600 gallons a minute.

(For additional data see table 1.)

Bm. 60. International Business Machines Corp., Endicott. About 370 feet east of Massachusetts Ave. and 130 feet south of River View Dr. Drilled by Rinbrand Well Drilling Co. in October 1937. Altitude 830 feet above mean sea level.

Casing:	12-inch.
Depth:	157 feet.
Screen:	22 feet with 1/16-inch slots set from 135 to 157 feet.
Static water level:	40 feet.
Drawdown:	60 feet.
Yield:	800 gallons a minute.
Installed pump capacity:	900 gallons a minute.

(For additional data see table 1.)

Bm. 61.* International Business Machines Corp., Endicott. About 240 feet east of Massachusetts Ave. and 130 feet south of River View Dr. Drilled by Rinbrand Well Drilling Co. in April 1935. Altitude 830 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Gravel, coarse with sand	18	18
Sand and clay, yellow	7	25
Clay, gray	15	40
Clay, gray and sand	5	45
Clay, gray	5	50
Sand and small gravel	20	70
Sand, coarse, some clay	11	81
Sand, coarse, and fine and traces of clay	31	112
Sand, coarse	10	122
Sand, medium	6	128
Sand, coarse and fine	15	143
Sand, coarse and gravel	4	147
Gravel	11	158
Shell rock	1	159
Rock, hard	2	161

Casing:	16-inch.
Depth:	159 feet.
Screen:	22 feet with 1/16-inch slots set from 136.5 to 158.5 feet.
Static water level:	(See fig. 5).
Drawdown:	21 feet.
Yield:	950 gallons a minute.
Installed pump capacity:	1,000 gallons a minute.

(Note: For additional data see table 1.)

Bm. 62. International Business Machines Corp., Endicott. About 175 feet east of Massachusetts Ave. and 130 feet south of River View Drive. Drilled by Rinbrand Well Drilling Co. in August 1934. Altitude 830.6 feet above mean sea level. Driller's log.

(Continued on next page)

Bm. 62. (Cont'd.)

	Thickness (feet)	Depth (feet)
Sand and gravel	22	22
Clay, grey	30	52
Sand, fine	10	62
Sand, coarse	8	70
Gravel, fine, and sand	54	124
Sand and some fine gravel	8	132
Gravel, fine, and sand	13	145
Sand and gravel	21	166

Casing: 12-inch.
Depth: 165 feet.
Screen: Johnson, 21 feet with 0.125-inch openings set from 143.8 to 164.8 feet.
Static water level: 27 feet.
Drawdown: 7 feet.
Yield: 750 gallons a minute.
Installed pump capacity: 1,200 gallons a minute.

(Note: For additional data see table 1.)

Bm. 63. International Business Machines Corp., Endicott. About 65 feet east of Massachusetts Ave. and 130 feet south of River View Dr. Drilled by Rinbrand Well Drilling Co. in September 1934. Altitude 834.7 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Sand and gravel	26	26
Clay, gray	33	59
Clay, gray, with small amount gravel	6	65
Sand, coarse and clay	2	67
Sand, fine, tight	26	93
Gravel, fine, and sand with some clay	4	97
Gravel, fine, and sand with considerable clay	18	115
Gravel, fine with considerable clay	10	125
Gravel, fine, and clay	5	130
Gravel, fine, and sand, coarse, some clay	4	134
Sand, coarse, and sone fine gravel and clay	3	137
Sand, quite fine and tight	6	143
Sand, fine	5	148
Sand, coarse to coarse sand and gravel	7	155
Gravel, fine, and clay, some sand	1	156
Gravel, coarse, and sand	15	171

(Continued on next page)

Bm. 63. (Cont'd.)

Casing:	12-inch.
Depth:	170 feet.
Screen:	Cook, 21 feet by 8-inch by 0.100-inch slots set from 149 to 170 feet.
Static water level:	36 feet.
Yield:	400 gallons a minute.

Well is not in use and is available for observation purposes.

Bm. 64. International Business Machines Corp., Endicott. About 15 feet east of Massachusetts Ave. and 130 feet south of River View Dr. Drilled by Rinbrand Well Drilling Co. in May 1934. Altitude 830 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Sand and gravel	23	23
Gray clay	30	53
Sand	35	88
Coarse sand and signs of fine gravel	7	95
Fine gravel and sand	58	153
Coarse gravel and sand	7	160
Fine gravel and sand	8	168
White clay	3	171
Rock at		171

Casing:	8-inch.
Depth:	170 feet.
Screen:	20 feet by 6-inch slotted pipe set from 150 to 170 feet.
Yield:	400 to 500 gallons a minute.

Well is not in use and has been capped.

Bm. 65. International Business Machines Corp., Endicott. About 30 feet west of Massachusetts Ave. and 130 feet south of River View Dr. Drilled by Rinbrand Well Drilling Co. in October 1934. Altitude 830 feet above mean sea level. Driller's log.

(Continued on next page)

Bm. 65. (Cont'd.)

	Thickness (feet)	Depth (feet)
Sand and gravel	31	31
Clay, gray	48	79
Sand and gravel	11	90
Sand and gravel, fine	2	92
Sand	8	100
Sand and gravel, fine, with clay	16	116
Sand and gravel, fine, with clay, sand predominating	13	129
Sand and gravel, fine, with clay	13	142
Sand and gravel, fine, no clay; sand 75%	11	153
Sand, fine	18	171
Sand	9.5	180.5
Rock at		180.5

Casing: 12-inch.
Depth: 181 feet.
Static water level: 45 feet.

Well is not in use and has been capped.

Bm. 66. Endicott Water Works Co., Endicott. East corner of En Joie Park at River Drive. Drilled in December 1944. Altitude 820 feet above mean sea level. Driller's log (see Boring No. 104 in Record of Borings section).

Case: 25-inch.
Depth: 90 feet.
Screen: 30 feet set from 60 to 90 feet.
Installed pump capacity: 1,500 gallons in a minute.

(Note: For additional data see table 1.)

Bm. 67. Endicott Water Works Co., Endicott. About 250 feet east of the southeast corner of the Water Plant yard, in En Joie Park. Drilled by Rinbrand Well Drilling Co. Altitude 820 feet above mean sea level.

Casing: 18-inch.
Depth: 155 feet.
Screen: None; well is open.
Yield: 2,500 gallons a minute.
Installed pump capacity: 2,500 gallons a minute.

(Note: For additional data see Table 1.)

Bm. 68. Endicott Water Works Co., Endicott. (See location sketch, fig. 8). Drilled by Rinbrand Well Drilling Co. Altitude 820 feet above mean sea level.

Casing:	18-inch.
Depth:	155 feet.
Screen:	None; well is open.
Yield:	2,500 gallons a minute.
Installed pump capacity:	2,500 gallons a minute.

(Note: For additional data see table 1.)

Bm. 69.* Endicott Water Works Co., Endicott. (See location sketch, fig. 8). Drilled by Rinbrand Well Drilling Co. Altitude 820 feet above mean sea level.

Casing:	12-inch.
Depth:	155 feet.
Screen:	None; well is open.
Static water level:	39 feet.
Yield:	1,200 gallons a minute.
Installed pump capacity:	1,200 gallons a minute.

(Note: For additional data see table 1.)

Bm. 70. Endicott Water Works Co., Endicott. (See location sketch, fig. 8). Drilled by Rinbrand Well Drilling Co. Altitude 820 feet above mean sea level.

Casing:	12-inch.
Depth:	155 feet.
Screen:	None; well is open.
Yield:	1,200 gallons a minute.
Installed pump capacity:	1,200 gallons a minute.

(Note: For additional data see table 1.)

Bm. 71. Endicott Water Works Co., Endicott. (See location sketch, fig. 8). Drilled by Rinbrand Well Drilling Co. Altitude 820 feet above mean sea level.

Casing:	12-inch.
Depth:	155 feet.
Screen:	None; well is open.
Yield:	1,200 gallons a minute.
Installed pump capacity:	1,200 gallons a minute.

(Note: For additional data see table 1.)

Bm. 72. Endicott Water Works Co., Endicott. (See location sketch, fig. 8). Drilled in February 1922. Altitude 820 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
No record	1	1
Clay, sandy	39	40
Sand (water)	3	43
White clay and stones	15	58
Hardpan	2	60
Sand, muddy	15	75
Sand, hard, solid	20	95
Sand (water)	5	100
Clay, sandy	15	115
Sand, muddy	20	135
Sand (water)	16	151

Casing:	12-inch.
Depth:	155 feet.
Screen:	None; well is open.
Static water level:	39 feet.
Yield:	1,200 gallons a minute.
Installed pump capacity:	1,200 gallons a minute.

(Note: For additional data see table 1.)

Bm. 73. Endicott Water Works Co., Endicott. (See location sketch, fig. 8). Drilled by Rinbrand Well Drilling Co. Altitude 820 feet above mean sea level.

Casing:	10-inch.
Depth:	155 feet.
Screen:	None; well is open.
Yield:	500 gallons a minute.
Installed pump capacity:	500 gallons a minute.

(Note: For additional data see table 1.)

Bm. 74. Endicott Water Works Co., Endicott. (See location sketch, fig. 8). Drilled by Rinbrand Well Drilling Co. Altitude 820 feet above mean sea level.

Casing:	10-inch.
Depth:	155 feet.
Screen:	None; well is open.
Yield:	500 gallons a minute.
Installed pump capacity:	500 gallons a minute.

(Note: For additional data see table 1).

Bm. 75. Endicott Water Works Co., Endicott. (See location sketch, fig. 8). Drilled by Rinbrand Well Drilling Co. Altitude 820 feet above mean sea level.

Casing:	10-inch.
Depth:	155 feet.
Screen:	None; well is open.
Yield:	500 gallons a minute.
Installed pump capacity:	500 gallons a minute.

(Note: For additional data see table 1.)

Bm. 76. Endicott Water Works Co., Endicott. This well number covers a battery of 18 wells, all of the same diameter and depth and located as shown on the sketch, fig. 8. All wells are pumped simultaneously through connections to a common air lift. Drilled by Rinbrand Well Drilling Co. Altitude 820 feet above mean sea level.

Casing:	6-inch.
Depth:	155 feet.
Screen:	None; wells are open.
Yield: (combined):	3,200 gallons a minute.

(Note: For additional data see table 1.)

Bm. 77. Endicott Water Works Co., Endicott. Near northeast corner of intersection of Page Ave. and Erie R. R. Drilled by Rinbrand Well Drilling Co. in February 1942. Altitude 830 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Dirt	10	10
Clay	113	123
Gravel, little clay, sand and little water	27	150
Clay	18	168

Casing:	8-inch.
Depth:	168 feet.
Static water level:	40 feet.

Well is not in use.

Bm. 78.* Endicott Water Works Co., Endicott. Northwest corner of intersection of West Franklin and June Sts. near Nanticoke Cr. Drilled by Rinbrand Well Drilling Co. in 1941. Altitude 820 feet above mean sea level. Driller's log.

(Continued on next page)

Bm. 78.* (Cont'd.)

	Thickness (feet)	Depth (feet)
Gravel, coarse	11	11
Gravel, fine and sand	9	20
Sand	8	28
Gravel (water)	4	32
Quicksand	15	47
Clay	116.5	163.5
Rock formation, broken and shelly	0.5	164
Gravel (water)	3	167
Clay	2	169
Sand, coarse and gravel (water)	10	179

Casing: 18-inch.
Depth: 188 feet.
Screen: 4 feet by 12-inch by ½-inch slots.
Static water level: 25 feet.
Yield: 400 gallons a minute.
Installed pump capacity: 1,500 gallons a minute.

Screen collapsed while developing well, thus accounting for present low yield.

(Note: For additional data see table 1.)

Bm. 79. Carl Selzar, R. D. #1, Vestal. About ¼ mile east of N. Y. State Hwy. #26, bridge over Susquehanna R., and between the old Vestal Rd. and the Susquehanna River. Drilled by Cline in 1914. Altitude 820 feet above mean sea level.

Casing: 5-inch.
Depth: 124 feet.
Screen: None; well is open.
Static water level: 24 feet.
Aquifer: Gravel.

Casing is seated in gravel. Plenty of water is available. Clay overlies the gravel.

Bm. 81. Vestal Water Commission, Vestal, North side of N. Y. State Highway #17 at west bank of Big Choconut Cr. Drilled by Kelly Well Drilling Co. in May 1945. Altitude 840 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Fill	10	10
Mixed clay, sand and gravel	15	25
Yellow clay and medium gravel	11	36
Fine to coarse gravel (water)	10	46
Fine to medium gravel (water)	5	51
Gravel, coarse and stones (water)	5	56
Clay, hard, brown, sandy	5	61
Sand, fine, dirty	10	71
Clay, gray and blue, with gravel, mixed	7	78
Clay, gray and blue mixed with gravel, hard	27	105
Blue shale	2	107
Rock, shale	2	109

Depth: 109 feet.

Well is not in use.

Bm. 83.* Tri-Cities Airport, Union. About 0.85 mile southwest of mouth of Nanticoke Cr. and about 0.15 mile southeast of Erie R. R. Drilled by George Thomas in 1943. Altitude 820 feet above mean sea level.

Casing:	6-inch.
Depth:	59 feet.
Screen:	10 feet.
Static water level:	27 feet.
Drawdown:	0.15 foot.
Aquifer:	Gravel.

Record of Borings

In Broome County all test wells, test holes and borings that are no longer accessible have been classed as BORINGS, and have been numbered consecutively, beginning with 1, proceeding in a general geographical sequence from NE to SW. Records of 30 borings used in this report appear in the following compilation. Locations are shown by fig. 2. No letter prefix is used with the boring number.

Boring 8. City of Binghamton. About 40 feet west of Chenango River and 900 feet south of northern City line. Drilled by Layne-New York Co. in 1934. Altitude 835 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Topsoil, loam sandy	7	7
Clay, sandy, reddish-yellow, thin layer gravel on bottom	28	35
Quicksand, yellow	30	65
Clay, sticky, reddish-yellow	92	157
Clay, thin, watery, blue	48	205
Clay, blue, gravel and large stones	3	208
Bluestone, hard shale, imprints of shells, at		208

(Casing has been pulled)

Boring 9. City of Binghamton. Near NE corner of State Street and Bevier Street. Drilled by Layne-New York Company in 1934. Altitude 843 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Fill, cinders	1	1
Clay, yellow, sandy	6	7
Boulders, gravel and sand	18	25
Clay, blue	11	36
Quicksand	13	49
Clay, sandy---top gray turning to blue at bottom	93	142
Rock, blue shale, with few shells	18	160

(Casing has been pulled)

Boring 11. City of Binghamton. Northwest corner of Mersereau and Brownson Streets. Drilled by Layne-New York Company in 1934. Altitude 861 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Gravel and sand	41	41
Clay, blue and red	4	45
Clay, sandy----sand very fine, clay streaks	48	93
Clay, tough, blue	68	161
Rock, blue shale, soft	7	168
Clay	1	169
Rock, blue shale, or sandstone, light green color	6	175

(Note: Depth to static water level on August 30, 1934 was 80 feet. Casing has been pulled.)

Boring 12. City of Binghamton. East bank of Chenango River about 600 feet south of DeForest Street bridge, at same location as well Bm. 26. Drilled by Layne-New York Co. in 1934. Altitude 838 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Cinder fill	1	1
Topsoil	6	7
Clay, soft, blue	7	14
Gravel, coarse, loose	9	23
Clay, soft, blue	49	72
Sand, coarse, blue, streaks of gravel	15	87
Sand, coarse, blue, small streaks of clay, blue	22	109
Clay, yellow	2	111
Hardpan	9	120
Clay, blue, tough	4	124
Boulders, gravel, heavy and sand, coarse, blue	7	131
Gravel and sand, hard packed; hardpan, thin layers, blue and boulders	16	147
Limestone	3	150
Boulders, heavy, gravel and blue clay	10	160
Rock, ledge	13	173

(Note: Depth to static water level, when bottom of hole was at 130 feet, was 16 feet. Casing has been pulled.)

Boring 13. City of Binghamton. About 250 feet southwest of DeForest Street bathhouse and 25 feet west of Chenango River. Drilled by Layne-New York Co. in 1934. Altitude 837 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Topsoil, loam, sandy	8	8
Rocks, stones and clay	17	25
Gravel, sand and clay	30	55
Clay, blue	3	58
Sand, coarse, or cemented gravel	12	70
Clay mixed with large gravel	2	72
Clay mixed with sand, coarse and rocks	18	90
Rock, blue shale	21	111
Rock, blue slate	8	119
Rock, hand bluestone ledge	3	122

(Casing has been pulled)

Boring 16. City of Binghamton. About 250 feet west of State Street and 500 feet north of Shear Street. Drilled by Layne-New York Company in 1934. Altitude 836 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Topsoil, loam	4	4
Clay, sandy, yellow	5	9
Gravel, sand and clay, yellow	5	14
Quicksand, yellow	121	135
Rock, shale, blue	5	140
Rock, ledge	6	146

(Casing has been pulled)

Boring 18. City of Binghamton. East bank of Chenango River at North end of Water Street. Drilled by Layne-New York Co. in 1934. Altitude 834 feet above mean sea level. Driller's log.

(Continued on next page)

Boring 18. (Cont'd.)

	Thickness (feet)	Depth (feet)
Topsoil	7	7
Sand, gravel and streaks of clay	6	13
Sand, brown	11	24
Gravel, streaks of sand and clay	9	33
Clay, yellow	22	55
Gravel and sand, wet	13	68
Clay, hard and dry	6	74
Gravel, sand and streaks of clay	4	78
Gravel and sand	10	88
Clay, blue	6	94
Gravel and sand with clay binder, wet	63	157
Rock, hard bluestone, ledge, at		157

(Casing has been pulled)

Boring 19. City of Binghamton. South bank of Susquehanna River about 600 feet west of Conklin Avenue at Holmes Crossing of Delaware Lackawanna and Western Railroad. Drilled by Layne-New York Company in 1934. Altitude 842 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Topsoil, loam	5	5
Clay, sandy, yellow	10	15
Gravel and sand, blue, coarse, hard packed	6	21
Hardpan	1	22
Rock	13	35

(Note: Depth to static water level, when bottom of hole was at 21 feet, was 13 feet. Casing has been pulled.)

Boring 20. City of Binghamton. Near east point of triangle formed by Court Street, Brandywine Avenue and Erie Railroad, at same location as well Bm. 25. Drilled by Layne-New York Company in 1934. Altitude 843 feet above mean sea level. Driller's log.

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Boring 20. (Cont'd.)

	Thickness (feet)	Depth (feet)
Topsoil, loam	5	5
Clay, sandy, yellow	11	16
Boulders, gravel and sand	13	29
Boulders, gravel and hardpan	5	34
Gravel and sand, coarse, gray	10	44
Hardpan	25	69
Rock sand	12	81
Rock	6	87

(Casing has been pulled)

Boring 31. City of Binghamton. Susquehanna River at downstream (west) edge of Rockbottom Dam about 180 feet north of Conklin Avenue. Drilled in 1934. Altitude of river bed 821.34 feet above mean sea level.

Rock elevation 821.01 feet above mean sea level.

Boring 41. City of Binghamton. Susquehanna River at downstream (west) edge of Rockbottom Dam about 200 feet south of South Street. Drilled in 1934. Altitude of river bed 813.65 feet above mean sea level.

Rock elevation 812.65 feet above mean sea level.

Boring 42. City of Binghamton, East abutment of Riverside Drive bridge over Chenango River. Drilled in 1923. Altitude 838 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Fill	16	16
Gravel, sand and clay	17	33
Clay	9	42
Rock, blue shale, at		42

(Casing has been pulled)

Boring 55. City of Binghamton. West abutment of Riverside Drive bridge over Chenango River. Drilled in 1923. Altitude 838 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Fill	6	6
Gravel, sand and clay	6	12
Rock, blue shale	9	21

(Casing has been pulled)

Boring 56. City of Binghamton. East bank of Chenango River at intersection of Wall and Ferry Streets. Drilled by Riley Engineering and Drilling Company in January 1936. Altitude 848 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Gravel and clay	30	30
Gravel and sand	5	35
Sand and clay	5	40
Gravel and clay	5	45
Sand and clay	10	55
Gravel and clay	5	60
Sand and clay	15	75
Gravel and clay	8	83

Boring 69. City of Binghamton. Ferry Street midway between Front Street and west bank of Chenango River. Drilled by Riley Engineering and Drilling Company in January 1936. Altitude 844 feet above mean sea level. Driller's log.

(Continued on next page)

Boring 69. (Cont'd.)

	Thickness (feet)	Depth (feet)
Gravel and sand	5	5
Clay	5	10
Clay, blue	20	30
Clay, blue and sand	5	35
Clay and gravel	5	40
Gravel	5	45
Gravel and sand	5	50
Gravel	5	55
Sand and clay	15	70

Boring 82. New York State Electric and Gas Corporation, Westover Station, Johnson City. About 250 feet north of D. L. and W. R. R., about 430 feet south of Choconut Creek and about 100 feet northeast of east railroad spur to Remington Rand Company plant. Drilled by Layne-New York Company in April 1942, Altitude 835 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Sand, gravel, boulders, and little clay	12	12
Little sand, gravel, boulders, and blue clay	17	29
Sand, boulders, clay and gravel; mostly clay, few boulders	11	40
Sand, yellow clay and gravel and boulders	15	55
Sand, fine and gravel, muddy	15	70
Sand, blue clay and boulders	13	83
Sand, gravel, clay and shale	7	90
Sandy shale	5	95

(Note: Pumped with air at 50 G.P.M. Casing has been pulled.)

Boring 87. New York State Electric and Gas Corporation, Westover Station, Johnson City. About 40 feet north of Choconut Creek and about

(Continued on next page)

Boring 87. (Cont'd.)

90 feet east of west spur to Remington Rand Co. plant. Drilled by Layne-New York Company in March 1942. Altitude 820 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Sand, gravel, boulders and little clay........	16	16
Sand, gravel, boulders........................	30	46
Sandy clay....................................	29	75
Sand, gravel, boulders and little clay........ (Showed little shale 91' to 94')	19	94
Sandy shale and little clay...................	6	100

(Note: Pumped with air at 200 G.P.M. with 18½ feet drawdown; well did not clear up. Pumping 150 G.P.M. with 14 feet drawdown cleared up noticeably. Casing has been pulled.)

Boring 92. New York State Electric and Gas Corporation, Westover Station, Johnson City. About 140 feet south of D. L. and W. R. R. bridge over Susquehanna River and about 270 feet southwest of east abutment of railroad bridge. Drilled by Layne-New York Company in July, 1942. Altitude 820 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Sand, gravel, little clay and boulders........	12	12
Sand, coarse, gravel, coarse, and boulders.....	24	36
Little coarse sand, little coarse gravel, plenty boulders and heavy clay............	32	68
Sandy blue shale and little clay..............	65	133

(Casing has been pulled)

Boring 93. Johnson City. North side of Endwell Street opposite the north end of 5th Street. Drilled in 1935. Altitude 835 feet above mean sea level.

Rock, hard bluestone, at depth of 119 feet.

(Casing has been pulled)

Boring 94. Endwell. South side of Main Street about 1700 feet east of Hooper Creek. Drilled by Rinbrand Well Drilling Company in September, 1941 for the Endicott Water Works Company. Altitude 820 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
No record	10	10
Sand and gravel	30	40
Clay and gravel	20	60
Gravel	10	70
Sand	45	115
Clay	13	128
Gravel	12	140
Slate rock	60	200

(Casing has been pulled)

Boring 95. Endwell. Northeast corner of Carmel Grove Road and County Club Road. Drilled by Rinbrand Well Drilling Company in October 1941 for the Endicott Water Works Company. Altitude 880 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Sand and gravel	40	40
Clay	2	42
Rock	10	52

(Casing has been pulled)

Boring 96. Endwell. Northwest corner of intersection of Hooper Creek and Erie Railroad. Drilled by Rinbrand Well Drilling Company in August, 1941 for the Endicott Water Works Company. Altitude 835 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Sand and gravel...............................	20	20
Clay..	40	60
Sand, fine....................................	10	70
Boulders......................................	10	80
Clay and boulders.............................	40	120
Hard sand.....................................	195	315
Bedrock, slate................................	31	346

(Note: Pumped dry at 30 G.P.M. Casing has been pulled.)

Boring 97. Endwell. North bank of Susquehanna River at Davis Street extended and below (southwest of) mouth of Hooper Creek. Located 80 feet east of well Bm. 58. Drilled for the Endicott Water Works Company. Altitude 820 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Topsoil.......................................	17	17
Sand and gravel...............................	13	30
Sand, fine, very few small stones.............	46.5	76.5
Clay, blue, with few pieces of wood...........	90.5	167
Shale, at.....................................		167

(Casing has been pulled)

Boring 101. International Business Machines Corporation, Endicott. Northwest corner Main and Delaware Streets. Drilled by Rinbrand Well Drilling Company in 1934. Altitude 840 feet above mean sea level. Driller's log.

(Continued on next page)

Boring 101. (Cont'd.)

	Thickness (feet)	Depth (feet)
Gravel and sand	30	30
Clay, gray	55	85
Clay, blue and sand	3	88
Sand, gravel and shale	4	92
Rock at		92

(Note: Ground water not encountered. Casing has been pulled.)

Boring 102. International Business Machines Corporation, Endicott. North Street between McKinley and Roosevelt Avenues. Drilled by Rinbrand Well Drilling Company in May 1934. Altitude 846 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Fill with concrete	8	8
Sand	19	27
Clay, gray	59	86
Rock, blue with shale breaks	64	150

(Note: Depth to static water level in sand was 23 feet during May, 1934. Yield 150 G.P.M. Casing has been pulled.)

Boring 103. International Business Machines Corporation, Endicott. Southeast corner of Rogers Street and Erie Railroad. Drilled by Rinbrand Well Drilling Company in May, 1934. Altitude 842 feet above mean sea level. Driller's log.

(Continued on next page)

Boring 103. (Cont'd.)

	Thickness (feet)	Depth (feet)
Fill	3	3
Topsoil	3	6
Gravel	4	10
Clay, blue	6	16
Gravel, fine	9	25
Clay, gray	43.5	68.5
Gravel	1.5	70
Rock with shale breaks (37 G.P.M. at 109')	39	109
Rock, hard, blue	16	125
Rock with shale breaks	17	142
Shale and rock	18	160
Rock, softer, blue with few shale breaks (40 G.P.M. at 168 feet.)	10	170
Shale with rock ribs	20	190
Shale rock (70 G.P.M.)	23	213

(Casing has been pulled)

Boring 104. Endicott Water Works Company, Endicott. Northeast corner of En Joie Park at River Drive. Located about 50 feet west of well Bm. 66. Drilled by Rinbrand Well Drilling Company in January 1942. Altitude 820 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Hardpan	10	10
Stone wall	8	18
Sand	64	82
Clay, some sand, little water	10	92
Gravel and clay	23	115
Gravel, fine and sand	8	123
Sand, coarse	25	148
Gravel	4	152

(Note: Well has been abandoned and casing filled.)

Boring 107. Endicott Water Works Company, Endicott. About 100 yards south of Erie Railroad and about 0.4 mile east of Nanticoke Creek. Altitude 840 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Quicksand................................	148	148
No record................................	42	190
Shale at.................................		190

Boring 108. Endicott Water Works Company, Endicott. In triangle formed by W. Main Street, Nanticoke Creek and Erie Railroad. Drilled by Rinbrand Well Drilling Company in April 1941. Altitude 820 feet above mean sea level. Driller's log.

	Thickness (feet)	Depth (feet)
Sand and gravel, small........................	30	30
Sand, coarse and gravel, large, little water...	10	40
Sand, very fine...............................	28	68
Sand, fine....................................	4	72
Sand and gravel, some water...................	6	78
Gravel and clay, washed and cemented..........	5	83
Sand, hard and clay...........................	21	104
Sand, coarse and clay, hard...................	22	126
Bedrock, slate................................	64	190

(Not accessible)

Boring 110. Endicott Water Works Company, Endicott. North bank of Susquehanna River about 1,800 feet above (northeast of) mouth of Nanticoke Creek and south of En Joie Golf Course. Drilled by Rinbrand Well Drilling Company in June 1941. Altitude 820 feet above mean sea level. Driller's log.

(Continued on next page)

Boring 110. (Cont'd.)

	Thickness (feet)	Depth (feet)
No record	10	10
Gravel, coarse	10	20
Sand, fine and gravel	40	60
Gravel, coarse (much water)	11	71
Gravel, coarse and boulders	18	89
Sand, coarse and clay	4	93
Gravel	3	96
Gravel (much water)	4	100

(Note: Depth to static water level in 1941 was 21 feet.)